Vertical distribution and trophic interactions of krill, sprat and gadoids in the inner Oslofjord during winter

by

Helene Brun

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ABSTRACT

Vertical distribution and trophic interactions of zooplankton and fish were studied at a 150 m deep station in Bunnefjorden – the innermost part of the Oslofjord - during winter 2005/2006. Focus was on the krill *Meganyctiphanes norvegica*, the small clupeid fish sprat (*Sprattus sprattus*) and gadoids, mainly whiting (*Merlangius merlangus*). Bunnefjorden is characterized by hypoxy in the bottom water, and the study was part of more long-lasting investigations addressing how hypoxy may influence the vertical distribution and the trophic interactions among the pelagic fauna in the fjord.

An upward looking EK60 120 kHz echo sounder deployed on the sea bed was used for collection of acoustic data of krill and fish. Krill and fish were sampled by trawling both day and night, to verify acoustic recordings, to establish size distributions and to examine feeding behavior of krill and fish. A CTD equipped with water bottles was used to obtain hydrographical data and water for oxygen and chlorophyll *a* measurements. Mesozooplankton was sampled using a WP2 net. Measurements of pigment content of stomach and hindgut of krill were examined to quantify the herbivore diet, while the carnivore diet was assessed microscopically by quantifying copepod mandible in the krill guts. Fish stomachs were dissected out, and analyzed for prey.

During daytime, acoustic scattering layers of the krill, *Meganyctiphanes norvegica*, and sprat, *Sprattus sprattus* were restricted to waters below 75 m and 130 m respectively. Krill and sprat ascended at dusk, a few migrated all the way to the surface, however upward migration was mainly arrested at 20-30 m for krill and 40-60 m for sprat. Sprat and krill were scattered throughout the water column at night. Haddock (*Merlanogrammus aeglefinus*) and whiting, both foraging on krill, were found in the upper and middle part of krill scattering layer during the day and in upper water layers at night. Whiting were also found to

predate on sprat. Although found in much less quantity in whiting stomachs than krill, one sprat do have a greater energy value than one krill.

The apparent avoidance of the surface layer by krill and sprat, even at night, could be a response to predators. It could not be explained by temperature, salinity, oxygen or chlorophyll *a* concentrations. Temperature and salinity below sill depth were fairly homogenous by depth, and did not have any explanatory power for the vertical distribution of krill and fish during the day, or the night distributions in deeper waters. Sprat and krill are fairly tolerable to low oxygen concentrations and did not seem to affect their distribution in this study, where oxygen levels never got below 1 ml O_2 l^{-1}. However, it has been proposed that sprat use the inner Oslofjord as a refuge for their gadoid predators during winter. In the case of this study, oxygen levels appeared to be just at the limit for gadoids to be able to exploit sprat in deep water. This could add to the antipredatory benefit of darkness at depth.

Gut content of krill was higher during the night, yet both ambient chl *a* and gut pigment levels were low. Feeding on algae by krill increased in the upper layers at night, while krill appeared to forage on copepods both day and night and throughout the water column. Feeding on phytoplankton and copepods makes krill less transparent and more vulnerable to visual predators, suggesting an advantage of feeding in the dark. Sprat foraged on copepods in the upper water layers during the night and in mid-water during the day. Sprat is a visual feeder, itself having visual predators, and this might be the reason why sprat migrates to the upper layers at night to feed and in the middle layer during the day where light intensity may be sufficient to detect its prey while at the same time being sufficiently low to give shelter towards own predators. There appears to be a trade-off between food intake and predation risks for both krill and sprat.

Smaller sized sprat did feed significantly more than larger sprat. Smaller sprat migrated to the surface waters at night, while larger appeared to stay in deeper waters, suggesting that small sprat need more energy to survive and maybe take higher risks to reach maturity faster and hence prioritized feeding during winter.

Krill and sprat feeding was related to prey abundance, and possibly also prey size and movements, which will affect both detectability and prey avoidance reactions.

1. INTRODUCTION

Vertical migrations by zooplankton and fish are a common element of oceanic communities in all oceans of both high and low latitudes (Robinson, 2003). A number of theories have been proposed to explain vertical migrations, most commonly being ascribed to a trade-off between optimizing food intake and minimizing exposure to predators, being further effected by the temperature of the water (Onsrud et al 2004). Warm waters are beneficial to speed up metabolisms when food is in excess (Wurtsbaugh & Neverman 1988), while cold water is advantageous to save energy when deprived of food (Hirche 1991). Plankton seem to optimize this trade-off by ascending to upper food rich, and often warm layers a nighttime in shelter of darkness and descend to deeper darker layers during the day to hide from visual predators (Tarling et al 2000, Onsrud et al. 1998).

Most fish are visual predators and foraging takes place during the day and in more shallow waters (Onsrud et al, 2004). However, small planktivorous fish are exposed to larger piscivorous predators that are active near the surface and may decrease their mortality by descending to darker waters during the day. In areas with limited depth, however, it may be enough light for fish to detect their prey throughout the watercolumn. Some fish detect their prey by the use of mechanosensory lateral-line system and some respond to mechanical stimuli imitating prey, thus being independent of vision in locating their prey (Onsrud et al 2004). Yet, a visual feeding mode is clearly the most efficient (Aksnes 2007).

Vertical oxygen gradients are another factor that may affect interactions between predator and prey when their tolerances for low oxygen waters differ. The inner part of Oslofjorden – Bunnefjorden - is often characterized by oxygen deficiency in the deep water, and in recent years there has been increased interest if the low oxygen waters may be exploited for predator avoidance. Special focus has been on the small clupeid sprat (*Sprattus sprattus*), which has been observed in high concentrations in low oxygen waters during winter (Røstad 2006). One of the hypothesis for work carried out in the Oslofjord lately, and one of the starting hypotheses for this study, is that overwintering sprat may exploit the hypoxic waters of Bunnefjorden to get away from their gadoid predators, which also commonly occur in the fjord (Røstad 2006). To assess this question, results are needed from years with different oxygen conditions in the deep water. As it turned out, in this particular winter oxygen concentrations in the basin water were low, yet above normal conditions for Bunnefjorden.

Little is known about the overwintering strategies of sprat and contradictory results exist on to which degree they are feeding actively during winter (Volan 2004, Røstad 2006). Norwegian spring spawning herring (*Clupea harengus*) seems not to be actively feeding during winter, and for this species the overwintering period has been characterized as an exercise in energy concervation and predator avoidance (Huse & Ona 1996).

Gadoids and clupeids are the major fish resources in the North Atlantic, and gadoids are main predators on clupeids, making it particular relevant to address their predator-prey relationships. They do, however, appear to feed on a variety of organisms depending on season, location and prey availability (Jiang & Jørgensen, 1994, Hislop et al, 1991). The krill *Meganytciphanes norvegica* commonly occurs in Oslofjorden, It may forage both as a herbivore and carnivore, and is an important prey organism for gadoids in this fjord (Onsrud et al, 1998, Kaartvedt et al, 2002, Onsrud et al, 2004, Onsrud et al, 2005).

The aim of this thesis is to describe and explain the vertical distribution of plankton and fish and their trophic interactions in the inner Oslofjord ecosystem during a winter period. The study will assess the physical and biological environment for krill, sprat and gadoids, determine their diel vertical migrations, and assess size distributions at different depths and time of the day and their diel feeding patterns.

2. MATERIALS AND METHODS

2.1 Study area

The study was carried out at a 150 m deep station in Bunnefjorden (59°48 N, 10°34 E) – the innermost part of the Oslofjord. The Oslofjord enters inland about 60 nautical miles from Skagerrak to Oslo. At Drøbak the channel to the inner part of the Oslofjord is 300 m wide and has a sill depth of 19 meters. Tidal amplitudes are low, the difference between high and low water only being 20-30 cm (Ruud, 1968). Hence, exchange of waters with outer regions is limited, particularly below sill depth. The inner part of the Oslofjord can generally be separated into surface water above sill depth and basin water below the 19 m sill depth (Onsrud & Kaartvedt, 1998). There are little variations vertically and seasonally in temperature and salinity in the basin water, however oxygen levels fluctuate and low levels of oxygen may occur in Bunnefjorden. Renewal of the water masses generally occurs every 3 years in Bunnefjorden in connection with cold winters and a high frequency of northerly wind (NGI, 2003 & Fagrådet for vann- og avløpsteknisk samarbeid i indre Oslofjord, 2000). Following years without water renewals, the deep, stagnant waters of Bunnefjorden becomes hypoxic, or even anoxic containing H_2S in the lower part of the water column. However, a water renewal the spring 2005, replaced the basin water in Bunnefjorden with well oxygenated waters, so that oxygen levels in April 2005 was >4ml/L even in the deepest part of the water column (Fagrådet for vann- og avløpsteknisk samarbeid i indre Oslofjord, 2006).

2.2 Sampling and study design

Sampling was conducted between November 2005 and January 2006 with the University vessel F/F "*Trygve Braarud*". There were 6 days of study; 24/25 November, 13/19 December and 4/5 January. Shipborn SIMRAD EK500 38kHz-120kHz echo sounders and a bottom mounted, upward looking EK60 120 kHz echo sounder was used for collection of acoustic data of krill and fish. Hydrographical and mesozooplankton sampling were obtained on three of the six days of study, and was performed during daytime. Temperature, salinity and oxygen were measured using a CTD and water samples for dissolved oxygen and chlorophyll *a* analysis were obtained. Mesozooplankton was sampled using a WP2 net. Krill and fish were collected by trawling, which was performed both day and night. Further details are given below.

2.3 Hydrography and chlorophyll *a*

Vertical temperature, salinity, and density profiles were obtained with a Neil Brown Mark III CTD (Conductivity temperature depth) from 0 m to 150 m. Niskin water bottles were mounted on the CTD. Water samples for measurements of dissolved oxygen and chlorophyll *a* were sampled every 10 m in the upper 50 m and a mix of every 10 and 20 m down to 150 m; 0, 10, 20, 40, 50, 70, 90, 100, 110, 130, 145 and 150 m.

Dissolved oxygen

The samples from the Niskin bottles were preserved and later analyzed in the laboratory based on the modification of the classical Winkler method by Strickland and Parsons (1968) for determination of dissolved Oxygen.

Chlorophyll *a*

Water samples (200 ml) for pigment analysis were filtered onto 2, 5 cm Whatman glass microfibre filters (GF/F) with pore size of 0.7 µm. The filters were placed in test tubes, wrapped in aluminum foil, and immediately frozen at -18 °C. In the laboratory, pigments were extracted with 10 ml 90% acetone and kept dark for 1 hour. After ½ hour samples were shaken and left for another ½ in darkness. The samples were then analyzed for extracted chlorophyll *a* by a Turner Designs spectrophotometer TD-700. The method is based on the fact that chlorophyll, when exposed to blue light, emits red light. Chlorophyll *a* exists in all algae and is therefore the primary pigment of interest.

The measurements were rectified for the possible presence of phaeo-pigments, which is decomposed chlorophyll. Phaeo-pigments also fluorescens, but less than the chlorophyll they originated from and at a higher wavelength. Chlorophyll degrades to phaeo-pigment by the loss of magnesium ion in the tetrapyroll chain which happens in an acidic environment (e.g. gastric acid in grazing animals). Hence, there were two measurements; one before 1-2 drops of 1M HCl and one after, to correct for phaeo-pigments. Chlorophyll *a* concentrations were then calculated from the difference before and after the acid;

ug chl.*a*/l = 0.53*1,8(Rf-Re)/V = 0.62*(Rf-Re)V

Rf = before hydrochloric acid
Re = after hydrochloric acid
V = volume filtered
0.53 = factor (ug chl.*a*/l) (fl.units/ml)
1,8 = Acid factor (Rf/(Rf-Re)

2.4 Mesozooplankton

WP2 net (working party no. 2) were used for mesozooplankton hauls. The WP2 net has an opening of 0.255 m^2 and a mesh size of 200µg with. The net was towed with a vertical towing speed of approximately 0.5m/s. The net was equipped with a Nansen closing device for depth stratified sampling. Filtered volume was estimated by multiplying tow distance with opening aperture.

Zooplankton were sampled at 5 depth intervals during the day; 0-20, 20-40, 40-85, 86-110, 112-145. Samples were preserved in 4% formalin solution. The fixed WP2 samples were rinsed in seawater, and samples that were too numerous were split into smaller fractions using a Kott splitter (Harris et al, 2000). The individuals were counted in a counting chamber and identified, preferably down to species using a Wild M3B stereo microscope.

2.5 Krill and fish distribution

2.5.1 Acoustics

Acoustic records, together with biological sampling, were made to assess the distribution of krill and fish. In this study a SIMRAD EK500 echo-sounders were used with 38 kHz ship-mounted transducer and 120 kHz submerged bottom-mounted transducer facing upwards at position 59°48 N, 10°34 E. The 120 kHz submerged bottom-mounted (150 m depth) echo sounder was in continuous operation during the survey time period and was coupled to a computer on mainland by a cable. All data was stored on the shore based PC by the software program EchoReceiver (Mork, 2000) and further processed by Sonar5 postprocessing software (Balk and Lindem, 2002). The Sonar5- program provides the opportunity to merge acoustic where the program chooses every n ping where n is proportional to the number of files that are merged. The more files that are merged, less information from each file is accounted for, but in this way a picture of the whole diel vertical migration sequence may be viewed.

From previous studies in Oslofjorden scattering layers displayed at 120 kHz, but not at 38 kHz, have been identified as krill (Kaartvedt et al, 2002). In this study krill was hardly caught in tows outside the 120 kHz scattering layer, while krill were the only potential targets sampled within the layer, apart for co-occurring sprat, which give a very different echo signature.

The 120 kHz echo sounder show both krill and fish, but only fish remain in the records when thresholds are set below a given value. In the current study, thresholds of -70 dB and -85 dB were applied. The lower threshold of -70 dB would largely remove the krill at their prevailing abundance, and remaining backscatter can be ascribed to fish. In this study sprat constituted the majority of the fish catch and the bulk of the scattering layer were most likely sprat. The higher threshold of -85dB would include krill, as well as fish.

2.5.2 Trawling

Pelagic trawling was conducted day and night to identify acoustic targets and collect krill and fish for size measurements and stomach analysis. Pelagic trawling was carried out on all the cruise dates except 19.12.05.

A so-called MultiSampler cod-end was used to obtain depth stratified samples during the pelagic trawling. The MultiSampler consists of 3 separate nets that can be opened and closed on command from the vessel, thus providing samples from three different depths in each haul. The trawl had an opening of 100m^2, and was towed at 2 knots.

12 hauls with three depth intervals in each haul were made on during the sampling period. Fishing depths were measured by a Scanmar trawl sensor. To assess the diel vertical distribution, sampling was performed both day and night, at depths standardized between cruises, yet selected to match the acoustic recordings as good as possible based on distribution during the first cruise and previous knowledge of main distribution patterns. Two approaches were made: In one set of samples, the 150 m deep water column was divided into three vertical strata, covered in oblique hauls: "near bottom" – 90 m; 90-60 m, and 60-0 m. The lower and upper of these intervals were again divided into three layers for more fine scale sampling.

2.5.3 Krill

When the trawl was on deck, the catch of krill was measured in liter, and a sub sample from each net was wrapped in aluminum foil envelopes and frozen. In the laboratory 30 krill from each haul and depth interval were identified to species, weighed, and the length was measured in mm form the tip of the rostrum to the tip of telson. Stomach and hindgut were then dissected and stomach fullness was subjectively estimated using an index from 0 (empty) to 4 (full). Furthermore, the pigment contents of stomach and hindgut were measured. The stomach and hindgut were placed in test tubes with 10 ml 90% $MgCo_3$- buffered acetone wrapped in aluminum foil and placed at 4ºC in the dark for 24 hours. Fluorescence was measured with Turner Design fluormeter TD-700, which was calibrated to 0-value before measuring with 90% acetone. The background level of fluorescence due to stomach tissues is, according to Simrad et al (1986), not significant. Chlorophyll content in the krill was calculated;

The total chlorophyll with phaeo-pigments: 0.53*(Rf)
Chl.*a*: 1,18*0,53 (Rf-Re)
Phaeo-pigment: total chlorophyll – chl.*a*

0,53 K-factor
1,18 Acid factor

Copepods may be major prey of *M. norvegica*, and their mandibles, which are composed of silica an chitin, are resilient to both the mechanical and chemical degradation in the krill stomach. Copepod mandibles can therefore be used to establish prey identity (Kalson & Båmstedt, 1994). After the chlorophyll measurements, stomachs were examined microscopically. The krill stomachs were covered with a drop of Downs medium (polyvinyllactophenol), copped and spread out on microscope slides to be further analyzed at 100X and 400X magnification. The species of prey copepods were identified based on shape and size of their mandibles.

2.5.4 Fish

Large fish in the catches - the gadoids whiting (*Merlangius merlangus*) and haddock (*Melanogrammus aeglefinus*) - were weighed and measured on the boat, and the stomachs frozen for further analyzes in the laboratory. The catch of sprat (*Sprattus sprattus)* was weighted, and a sub sample of 30 individuals from each haul from each depth was frozen for further analysis in the laboratory.

In the laboratory the spat were weighed and measured (both the total and the caudal length). Fish stomachs were dissected out and state of digestion and stomach fullness were categorized using an index from 1(undigested) to 5 (fully digested), and 0 (empty) to 6 (full) respectively. Prey organisms were identified to the lowest possible taxon and counted using a Wild M3B stereo microscope.

2.5.5. Statistical methods

Results were tested statistically using paired t-test and Mann Witney U test. The latter test does not require normal distribution and homogenous variance among the data, and results from both tests are included here, referred to at P (paired t-test) and mw (Mann Witney).

3. RESULTS

3.1 Environmental data and potential food for krill and fish

3.1.1 Hydrography

Temperature at 2 m varied between surveys with a maximum temperature of 9°C in November and a minimum temperature of 3°C in January (Fig.1a). The temperature differences between the sampling periods mainly occurred in the upper 18 meters, below this there was little variations by time and depth. Below 60 m temperature was fairly homogenous for all three surveys (7, 5-7, 6°C).

Salinity 2 m below the surface varied from 22, 9 ppt in November to 24, 7 ppt in December and up to 29, 4 ppt in January. Salinity increased rapidly by depth in the upper few meters (down to about 10 m). Salinities in waters below this were reasonably constant in all three surveys; between 31-33 ppt; although with a slight increase down to 60 m in November and December, and a slight decrease below the upper few meters in January.

The deep water of Bunnefjorden was oxygenated throughout the survey period (Fig. 1b). Overall, oxygen values declined rapidly by depth down to ~2 ml l^{-1} at ~20 m (10 m in January). Values varied somewhat down to 50-60 m; thereafter generally laying between ~1.5 to 2 ml l^{-1} for most of the water column. Minimum values were 1, 48 ml l^{-1} at 50 m in November and 1, 28 ml l^{-1} at 150 m in December. The lowest values during the investigation were measured at 150 m in January (1, 02 ml l^{-1}).

3.1.2 Chlorophyll *a*

Chlorophyll *a* values were always low, with surface values between ~0.2 and ~0.4 µg l^{-1} for the three sampling periods (Fig. 1c). Chlorophyll levels rapidly declined in the upper 10 m. Values for the remainder of the water column were close to 0, 01µg l^{-1}, apart for a peak measurement of 0.3 µg l^{-1} at 110 m in November.

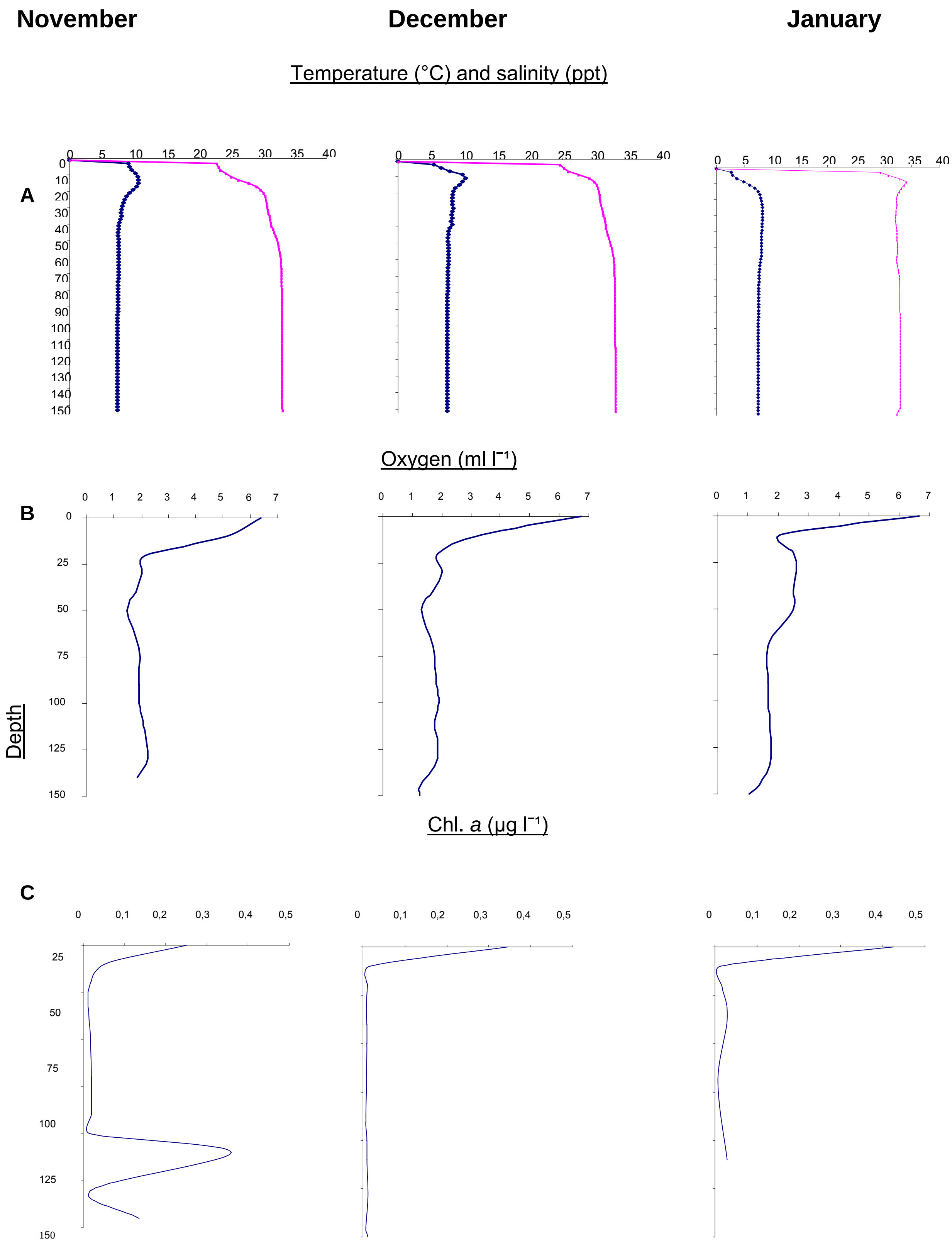


Fig. 1. Vertical distributions of a) temperature( )and salinity( ) b) oxygen; and c) chl *a.* for November 05, December 05, and January 06.

3.1.3. Copepods

The highest number of copepods was found in November, with the largest concentration in the 0-20 m upper layer (Fig. 2). In December and January the number of copepods in the upper layer declined. Lowest numbers were found from 20-85 m during all three surveys. High concentrations of copepods were located in the deeper water layers, especially from around 120- 140 m, where over wintering *Calanus spp* dominated in all three months (Fig. 3), with only slightly lower numbers in January.

The most dominant genera in the water column were *Oithona, Calanus, Pseudocalanus, and Acartia* (Table 1). The smaller genera like *Acartia* and *Pseudocalanus* dominated the upper layers, while the larger *Calanus* dominating the deeper layers. *Oithona* seemed to occur in high numbers through the whole water column.

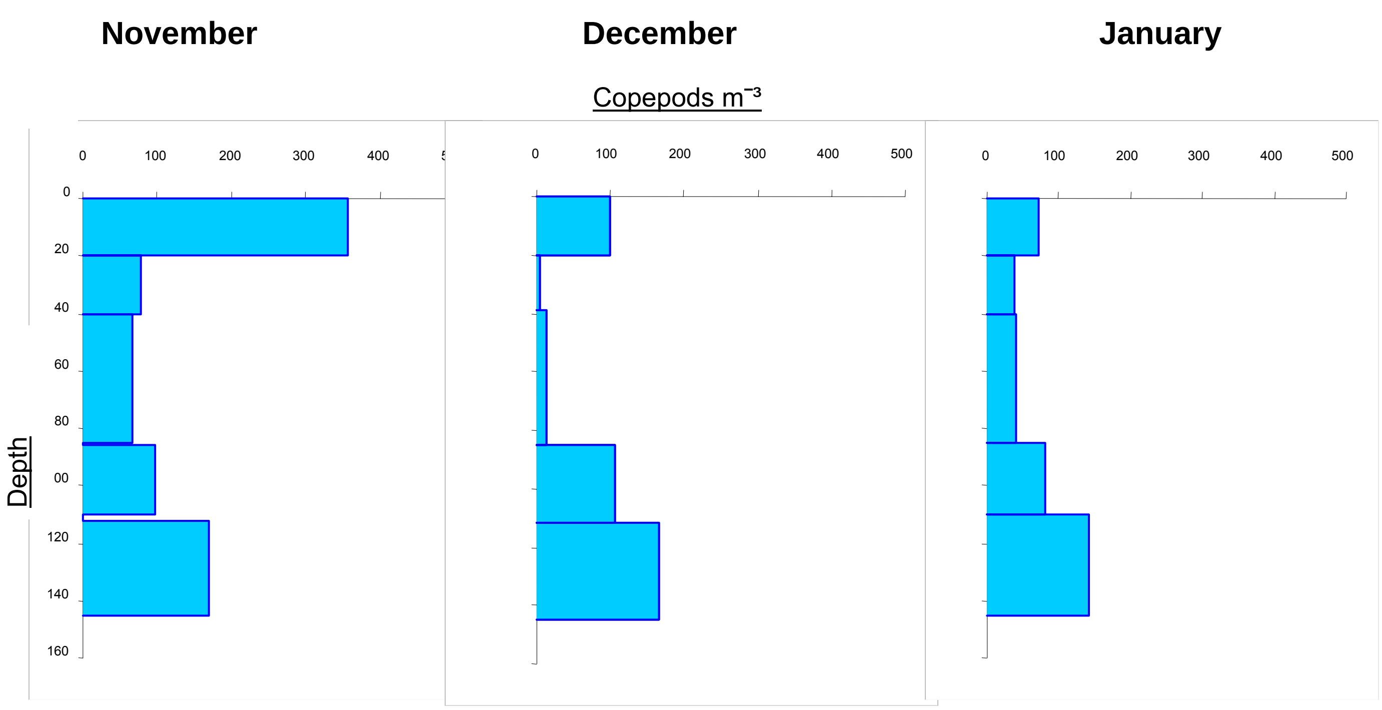


Fig. 2. Vertical distribution of all copepods in the water column

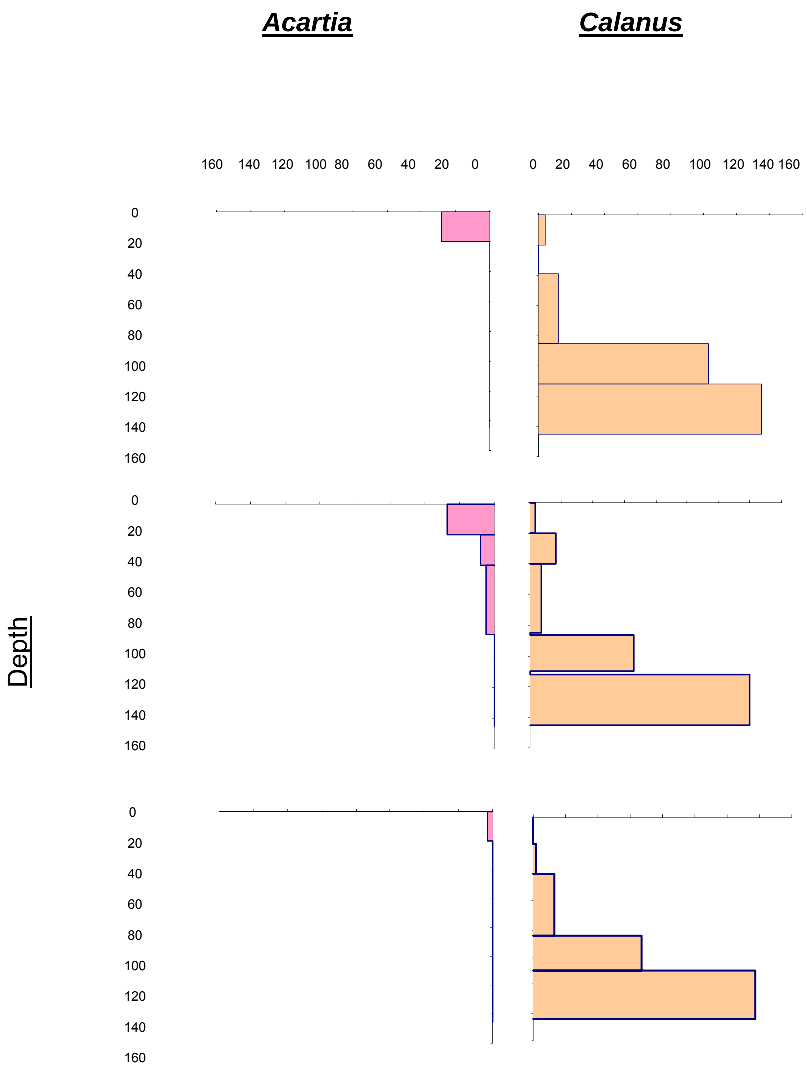


Fig. 3. Vertical distribution of *Acartia spp* and *Calanus spp.*

Depth (m)	*Calanus spp*	*Acartia spp*	*Temora longicornis*	*Euchaeta norvegica*	*Metridia lucens*	*Oithona spp*	*Microcalanus pusillus*	*Pseudocalanus elongatus*	*Onchea*	Others
November										
0-20	20	140	-	-	-	500	-	1190	10	-
20-40	17	43	-	-	7	250	3	-	17	-
40-85	84	63	-	1	-	464	5	3	34	126
85-112	410	3	-	-	-	173	-	26	-	-
112-145	1201	-	-	1	2	250	-	-	-	-
December										
0-20	20	145	-	-	-	56	-	284	-	10
20-40	2	-	-	-	-	13	-	3	-	-
40-85	144	1	-	-	-	14	-	6	-	-
85-112	725	3	-	-	1	10	-	6	-	-
112-145	1162	-	-	1	-	228	-		20	-
January										
0-20	2	15	-	-	-	258	-	62	34	
20-40	12	-	-	-	2	140	-	36	7	
40-85	151	1	-	-	2	266	-	39	9	
85-112	434	-	-	-	1	90	-	5	2	1
112-145	1246	-	-	-	-	47	-	2	6	1

Table 1. Total amount of of copepods WP2 net

3.2 Distribution of krill and fish

3.2.1 Acoustic studies

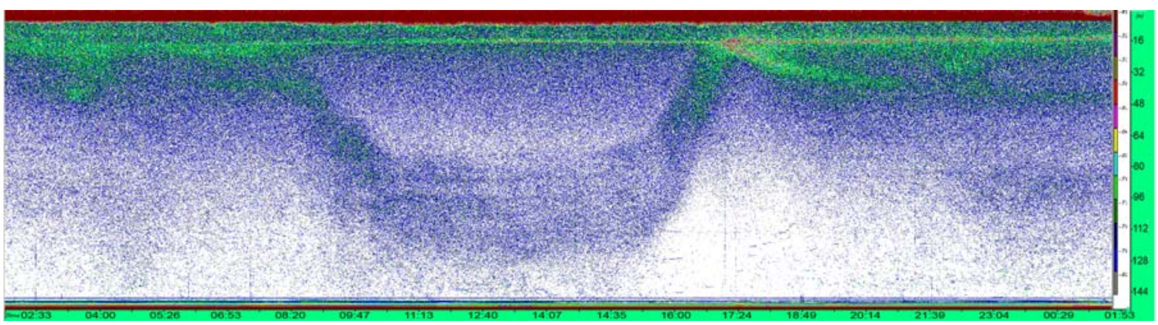
One acoustic scattering layer was recorded in November, while an additional principal layer was recorded in December and January (Fig. 4 & 5). The shallowest layer (and the only layer recorded in November), was ascribed to krill. This layer was not recorded at the 38 kHz ship borne echo sounder (not shown), and the records largely disappeared when lowering the Sv-threshold to – 70 dB. Trawl catches in these structures (see below) were dominated by krill.

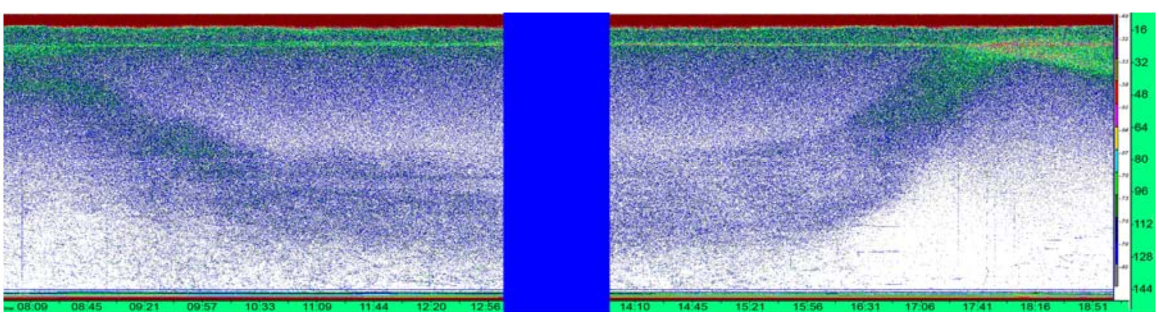
The layer below was also recorded at 38 kHz (not shown) and when lowering the Sv-threshold (Fig. 5), thus being composed of larger and stronger acoustic targets. Trawl catches in this structure were dominated by sprat (see below), and this layer is ascribed to sprat.

Krill

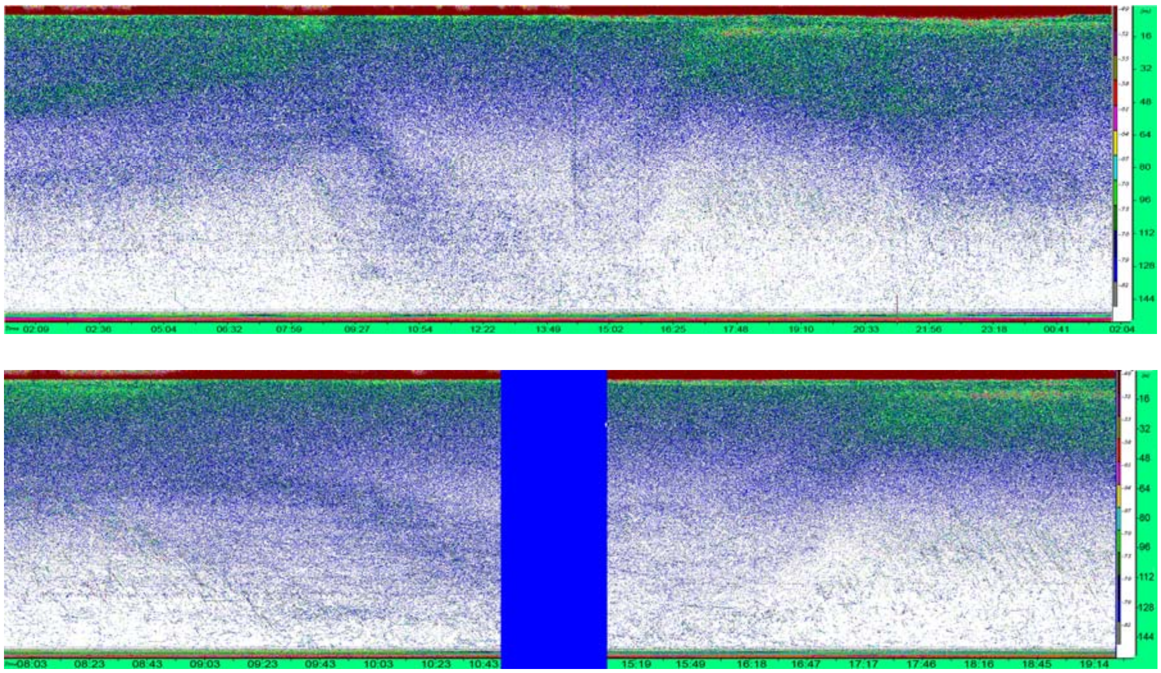
The krill carried out diel vertical migrations (Fig. 4). During the day, the krill layer was restricted to waters deeper than ~75 m in November and ~85 m in December, while a daytime scattering layer of krill was not apparent in the diel plots due to low abundance in January. In November and December, the krill migrated nearly all the way to the surface at dusk, followed by a slight sinking, while the nighttime distribution was not clearly established in January. Figures below show distribution of krill and sprat during a 24 hour cycle and 3-4 hours around dusk and dawn.

November





December



January

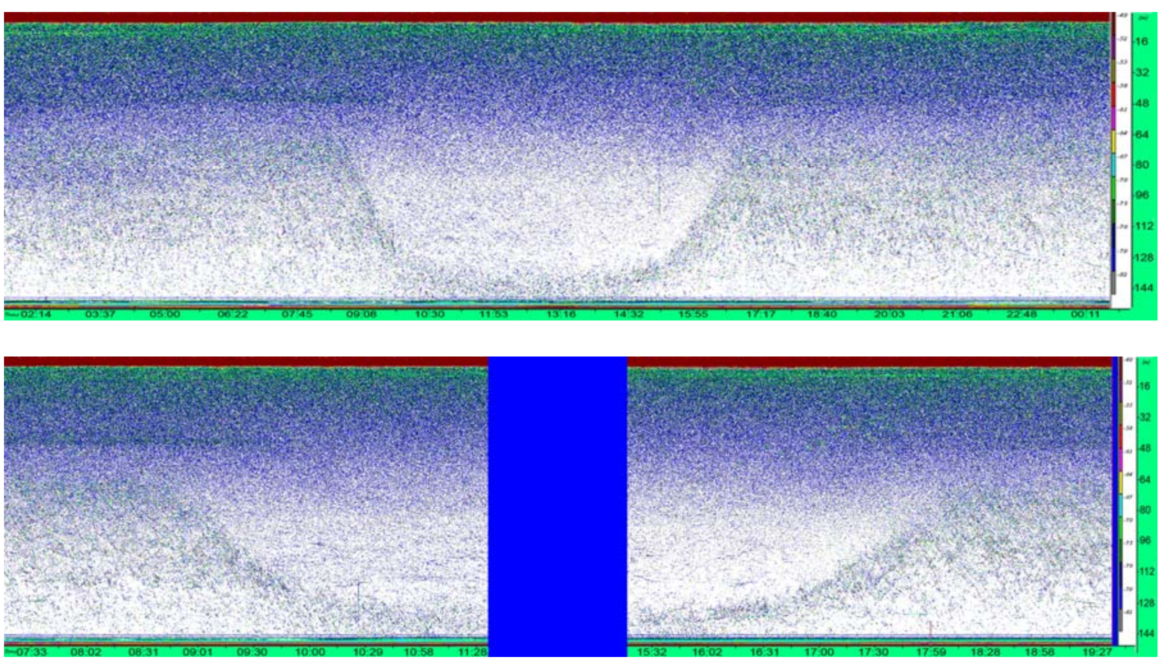


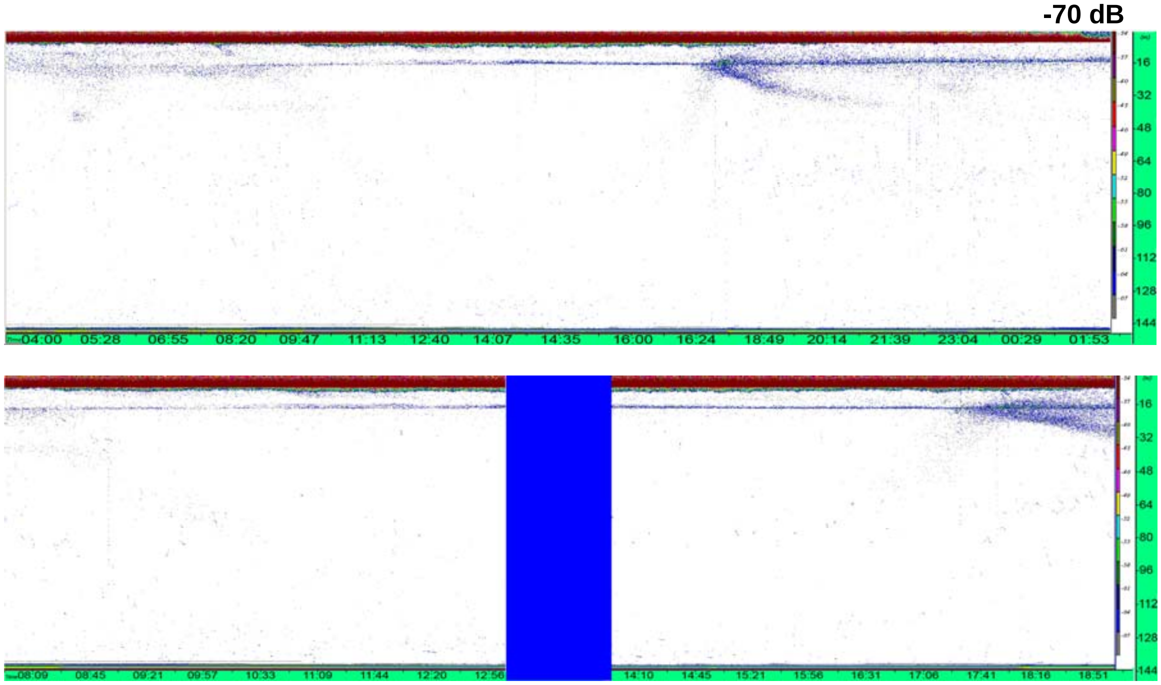
Fig. 4. Acoustic recordings (120-kHz) during a day and at dusk and dawn for a) November 2005; b) December 2005; and c) January 2006. S_v threshold of -85dB

Sprat

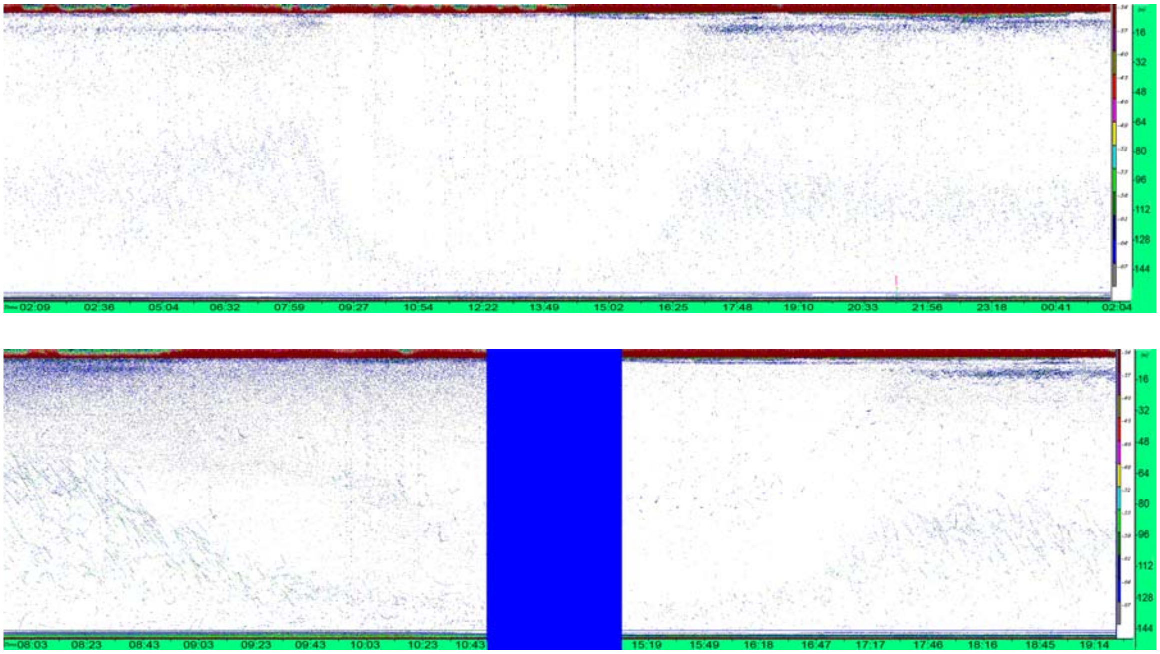
Only modest amounts of sprat appeared in the fjord in November and were hardly recorded acoustically (Fig. 5). In December and January a scattering layer of sprat appeared below 130 m during the day (Fig. 5). The sprat ascended at night, but not as shallow as the krill, forming a layer in mid water. The sprat ascended later, and descended earlier, than the krill.

November

-70 dB



December



January

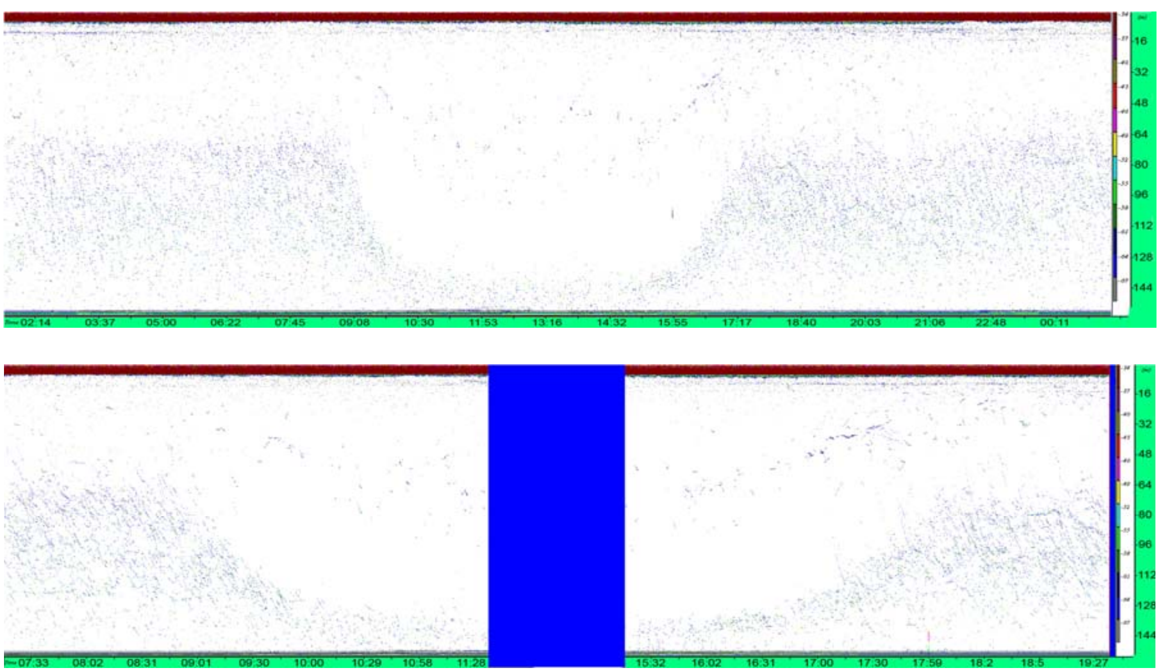


Fig. 5. Acoustic recordings (120-kHz) during a day and at dusk and dawn for a) November 2005; b) December 2005; and c) January 2006. S_v threshold of -70dB

3.2.2 Trawling

Krill (*M. norvegica)* and sprat (*S. sprattus*) dominated trawl catches in all surveys together with a lower number of haddock and whiting.

Krill

During daytime catches, krill were caught from 60 m to 120 m, and no krill was caught from 60 m and above in November (Fig. 6a+b). Trawling during night was not conducted in November.

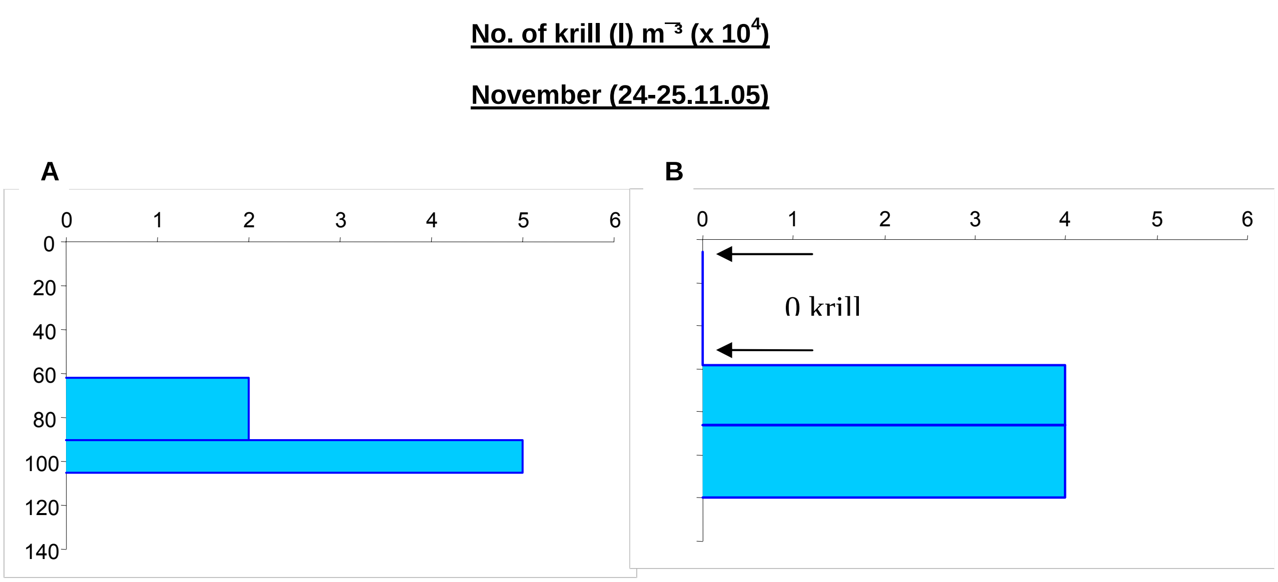


Fig. 6. No. of krill (*M. norvegica*) (I) m^{-3} (x 10^4) in pelagic trawl catch. A) 24.11.05 at time 12.55-13.29; and B) 25.11.06 at time 09.55-10.54.

In December krill was caught deeper than 60 m during the day (Fig. 7a+b). High numbers were caught from 112-120 m (Fig 7b). During night trawls, krill was caught throughout the water column, with highest catches in the upper 60 m, especially from 20-30 m (Fig. 7).

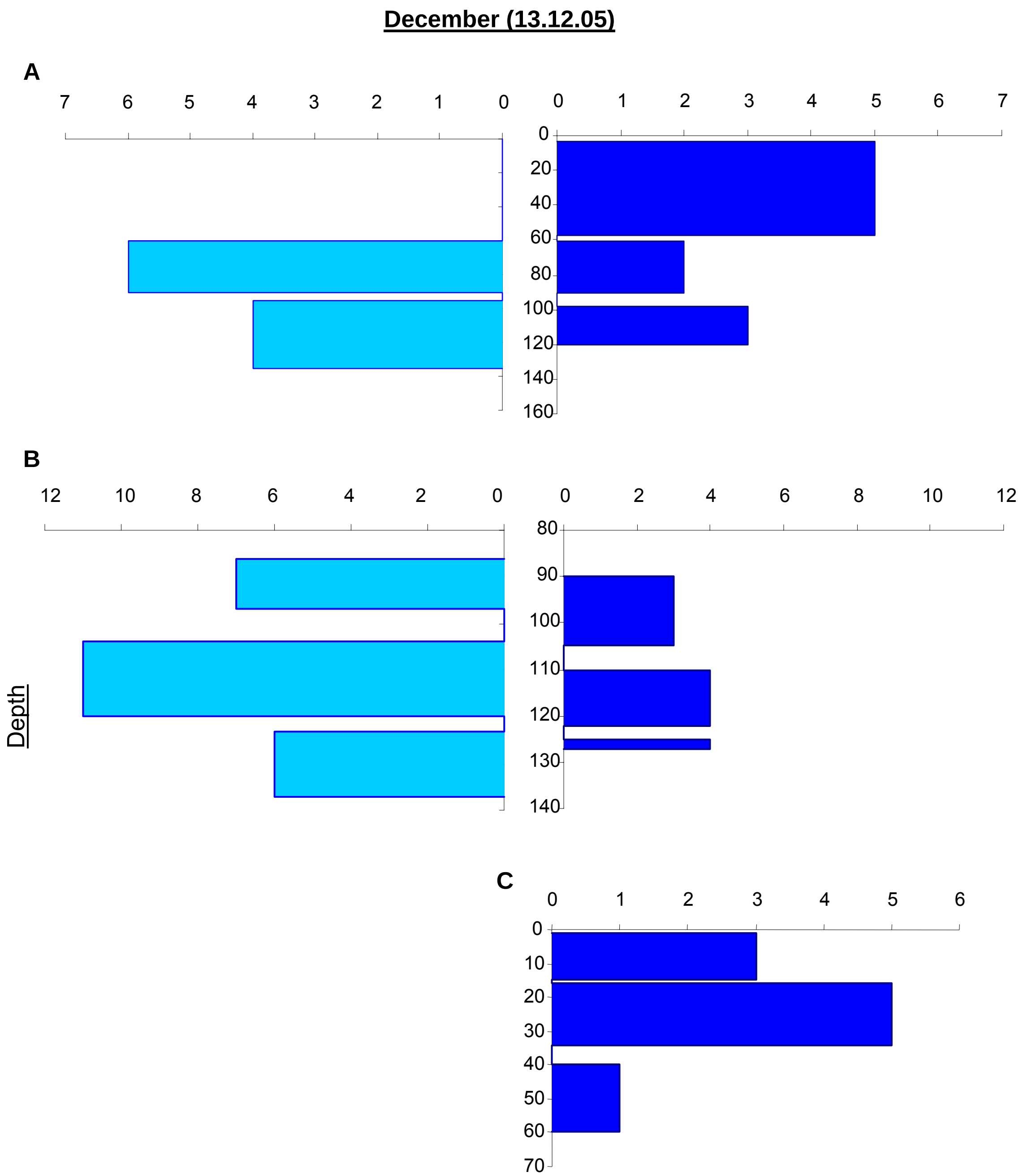


Fig. 7. No. of krill (*M. norvegica*) (I) m^{-3} (x 10^4) in pelagic trawl catch. A) Whole water column. Day(11.43-12.25) and night (18.06-18.55); B) Deeper water layer. Day (14.13-14.47) and night (21.00-21.36); and C) Upper water layer. Night (19.37-20.20).

January followed the same pattern as December, yet with krill apparently being caught somewhat deeper during the day compared to November and December (Fig. 8a, b, c). During night, krill were caught through the whole water column, but with a larger concentration in the upper 60 m. When dividing the upper 60 m in three depth intervals, nocturnal catches were relatively low in the upper 20 m (Fig. 8b).

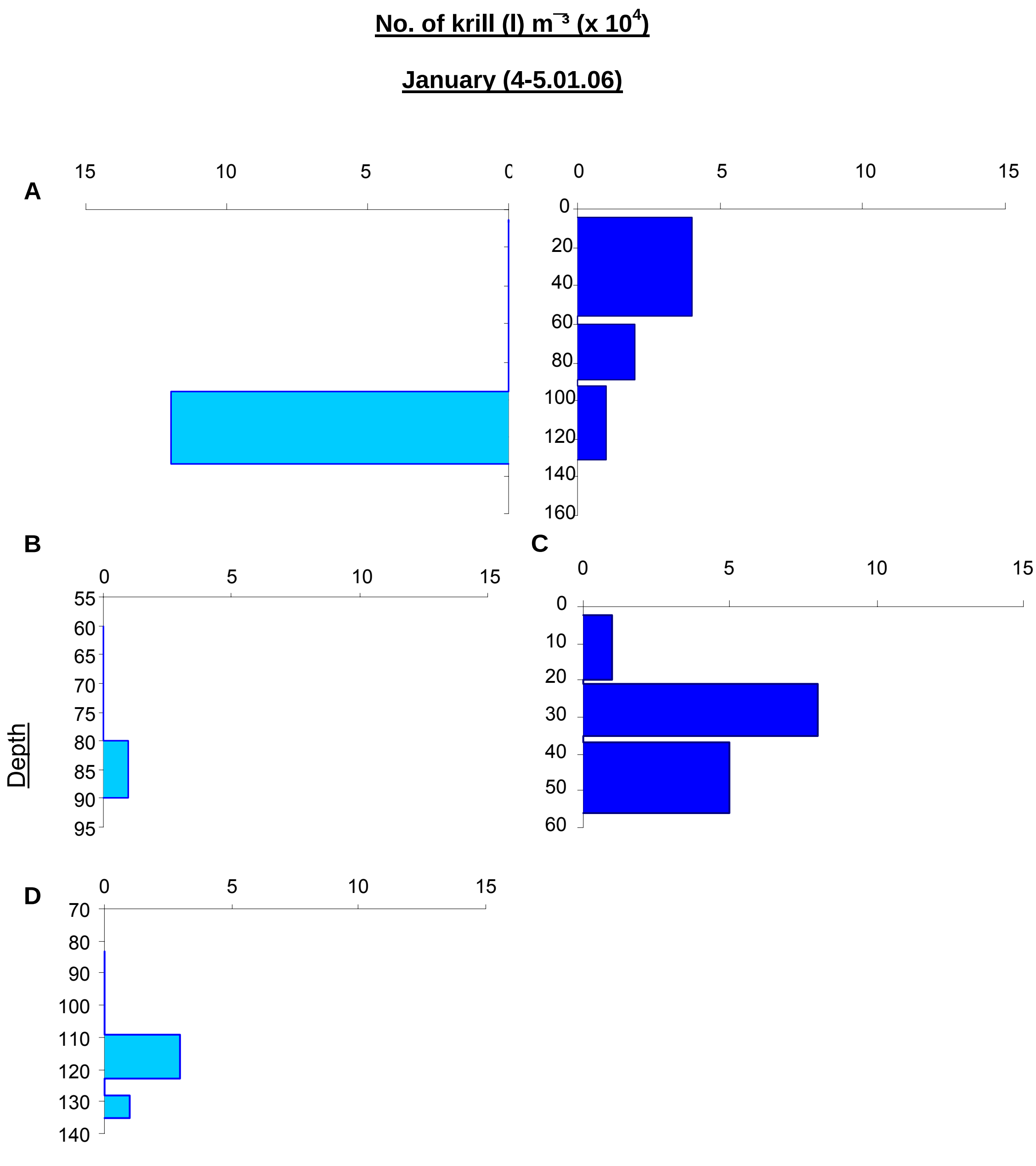


Fig. 8. No. of krill (*M. norvegica*) (I) m^{-3} (x 10^4) in pelagic trawl catch. A) Whole water column. Day (11.57-13.00) and night (19.31-20.21); B) Middle water layer. Day (11.22-12-12); C) Upper water layer. Night (20.56-21.40); and D) Deeper water layer. Day (12.55-13.39)

Sprat

In November, trawling was only carried out at daytime. Sprat was most abundant from 90-120 m (Fig. 9), with low numbers caught in tows extending up to 60.

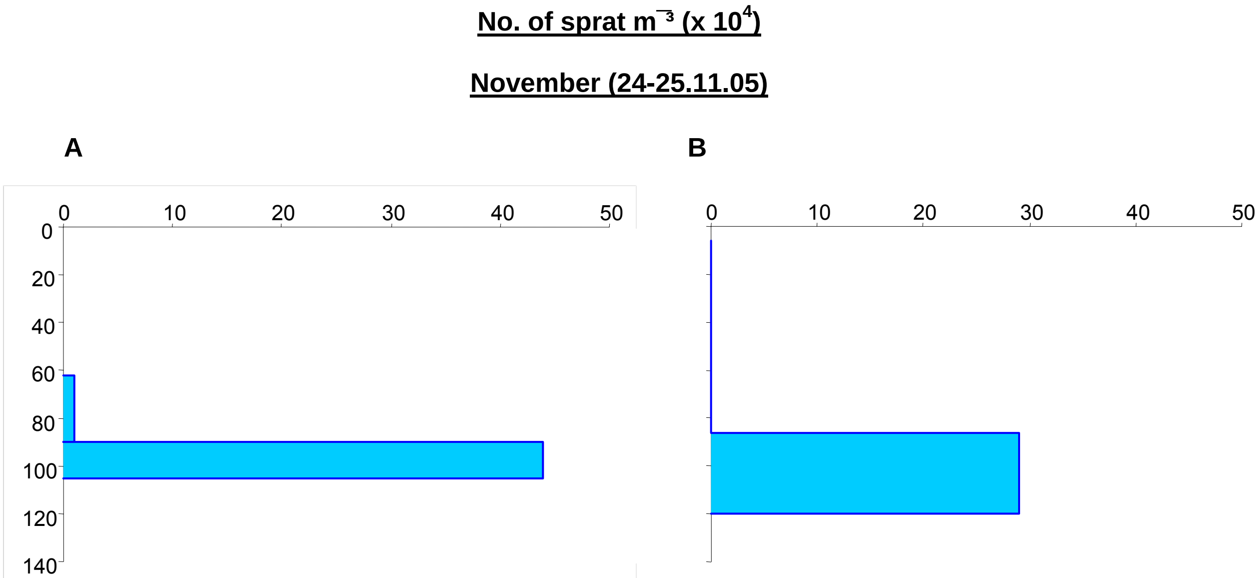


Fig. 9. No. of sprat (*S.sprattus*) m^{-3} (x 10^4) in pelagic trawl catch. A) 24.11.05 at time 12.55-13.29; and B) 25.11.06 at time 09.55-10.54.

Catches of sprat were higher in December. During the day sprat was most abundant from 100-140 m, with the highest amounts in the depth interval from 125-140m (Fig. 10a+b). Also night catches revealed higher concentration in deeper layers (below 60 m), however a few sprat were caught from the surface to 15 m, and from 40 to 60 m (Fig. 10a+c).

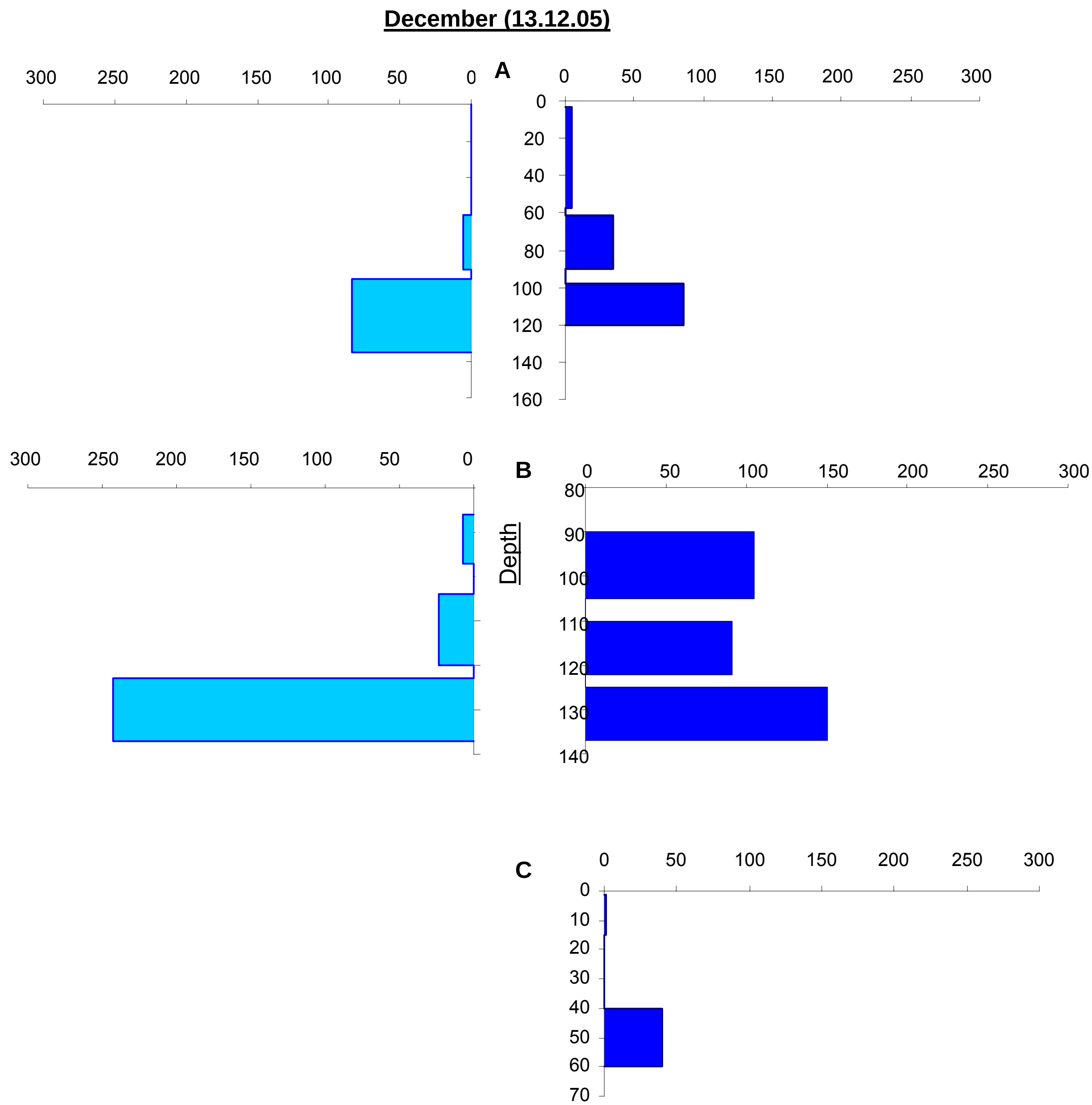


Fig. 10. No. of sprat (*S. sprattus*) m^{-3} (x 10^4) in pelagic trawl catch. A) Whole water column Day(11.43-12.25) and night (18.06-18.55); B) Deeper water layer. Day (14.13-14.47) and night (21.00-21.36); and C) Upper water layer. Night (19.37-20.20).

January had the highest number of sprat in trawl catches. During daytime, catches were highest from 100-140 m, although there also was sprat in tows from 100 to 60 m (Fig. 11a+b). Depth-resolved sampling in the deeper layers demonstrated the highest abundance of sprat from 130-140 m (Fig. 11d). Night time catches showed sprat through the whole water column, yet with the highest concentration in deeper waters. In the upper water layer sprat were most numerous from 40-60 m.

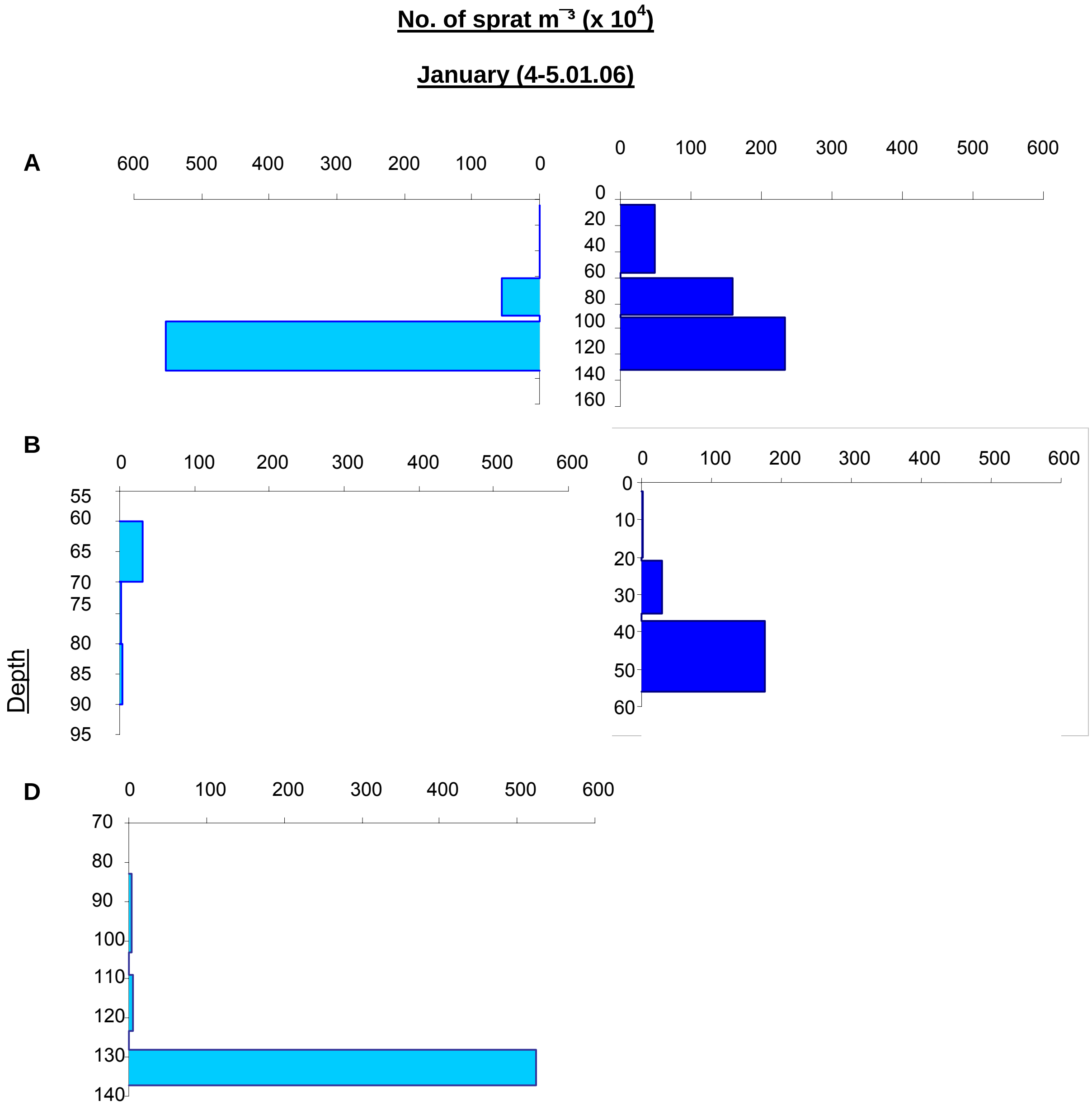


Fig. 11. No. of sprat (*S.sprattus*) m^{-3} (x 10^4) in pelagic trawl catch. A) Whole water column. Day (11.57-13.00) and night (19.31-20.21); B) Middle water layer. Day (11.22-12-12); C) Upper water layer. Night (20.56-21.40); and D) Deeper water layer. Day (12.55-13.39)

Gadoids

Haddock was only caught in November, and whiting in December and January; both in low numbers (4 and 30 respectively). During day time trawl in November haddock was found at depths from 60 m to 80 m (Fig. 12). Catches of whiting in daylight were restricted to deeper water layers from 60 m to 130 m. Whiting was most abundant from 80-100 m. Night trawl catches demonstrated the occurrence of whiting in the upper 60 m, with the highest concentrations from 20- 40 m (Fig. 12).

No. of haddock, *Melanogrammus aeglefinus,* and no. of whiting, *Merlangius merlangus* m^{-3} (x 10^4) from all trawl catches.

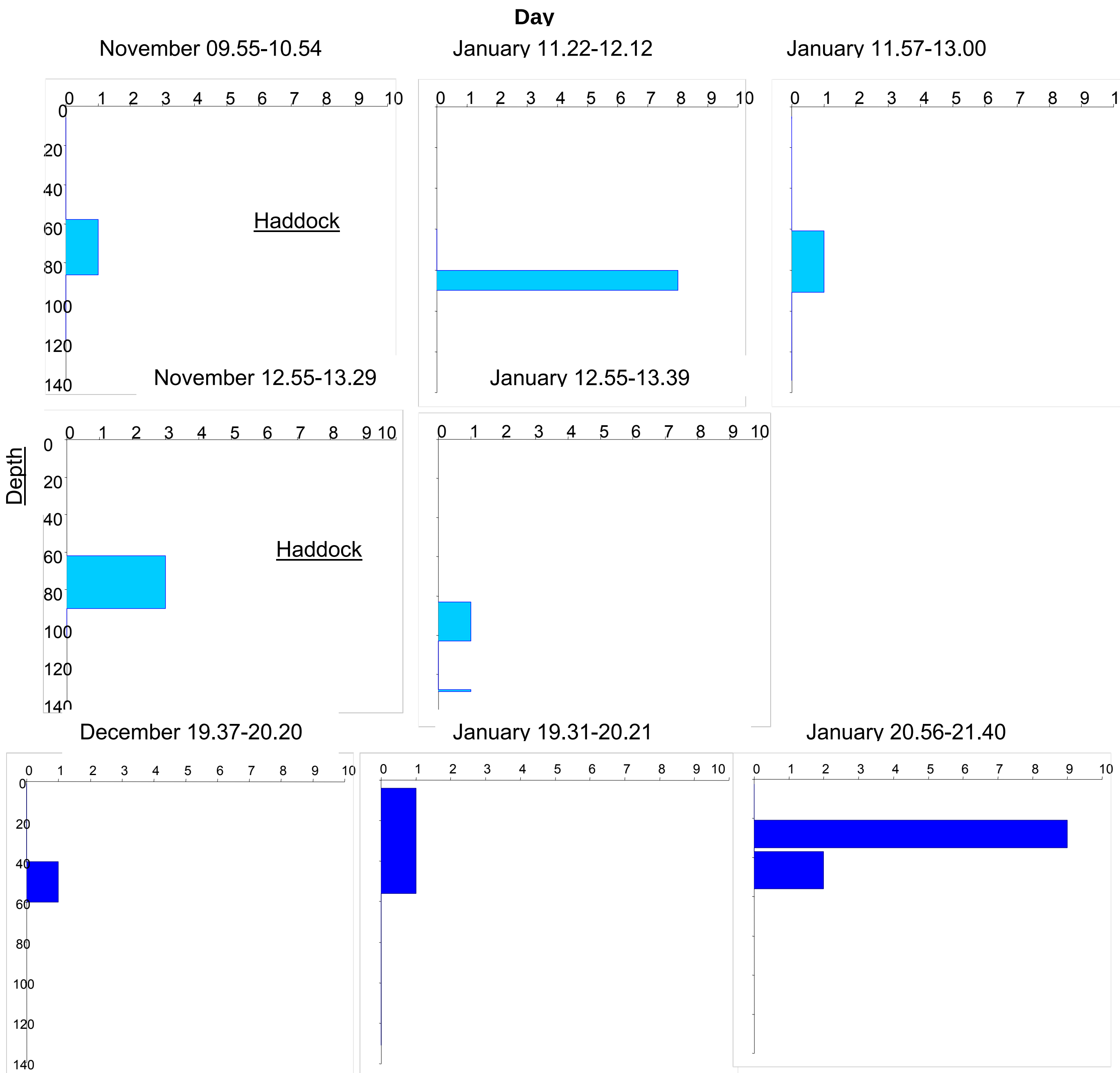


Fig. 12. No. of haddock, *Melanogrammus aeglefinus,* and no. of whiting, *Merlangius merlangus* m^{-3} (x 10^4) from all trawl catches, following the time of the day. Haddock only in November catches.

3.3 Size distribution krill and fish

3.3.1 Krill

Krill length- and weight measurements were only conducted in December.

There was a significant difference between krill length caught in the upper layers (0-60 m) and in the lower layers (90-135m) during the day (P=0,026) with larger krill closer to the bottom, though there were no significant difference in the weight of the krill (P=0,197)(Fig. 13c).

At night, in the upper layers, there was a significant difference in krill length distribution with larger krill near the surface (1-15 m) and smaller krill in mid-water (40-60m) (P=0,023, mw=0,0093), there was, however, no difference between krill weight (Fig. 13d).

In the deeper parts of the water column krill lengths showed no significant difference (P=0,068, mw=0,261) between day and night (Fig. 13a), however the krill weight decreased significantly during the night (P=0,004, mw=0, 0027) (Fig. 13b).

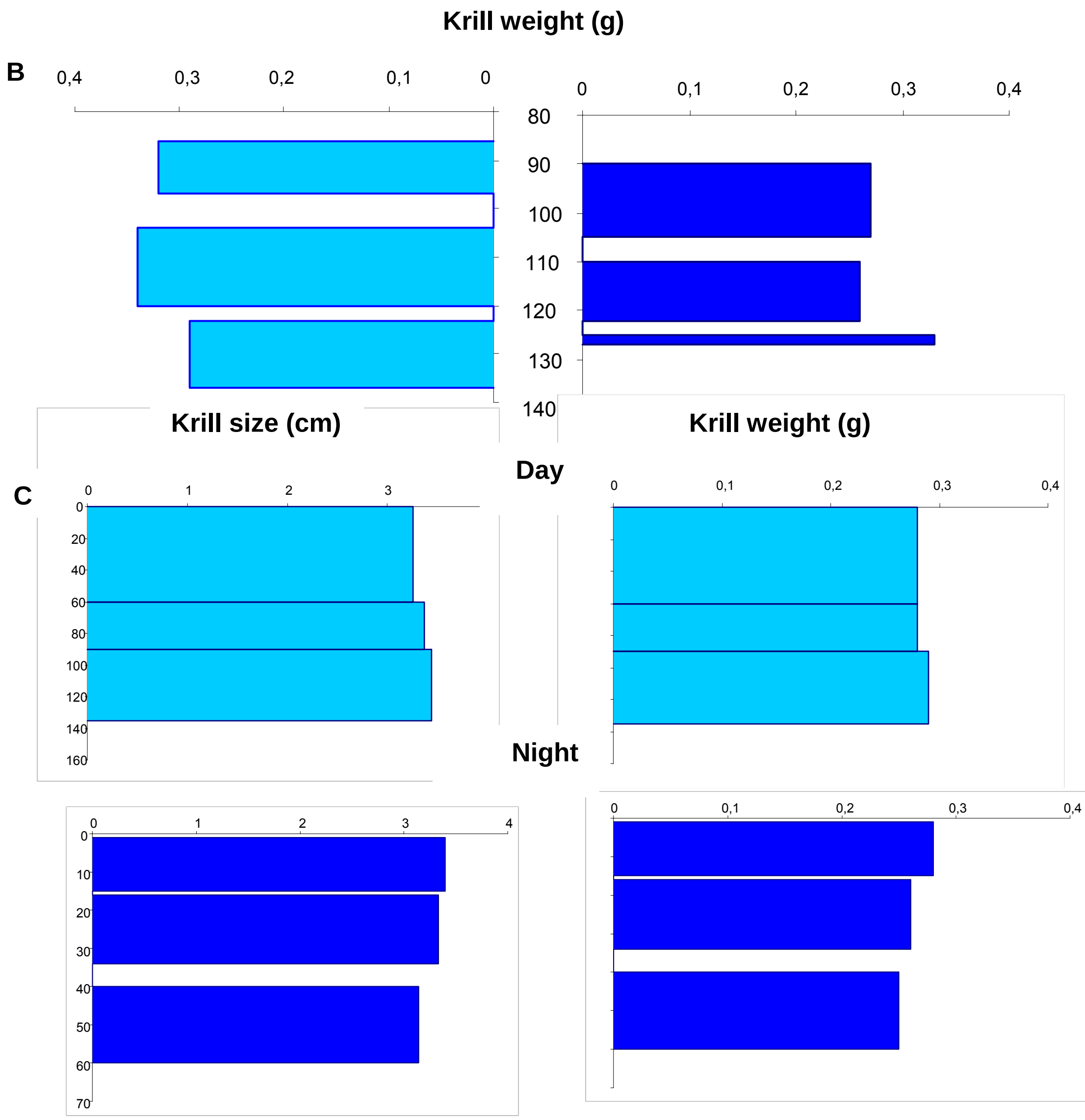


Fig. 13. Krill (*M. norvegica*) size (cm) in December 2005. A) Size (cm) in deeper layers day (14.13.14-47) and night (21.00-21.36); B) Weight (g) in deeper layers day and night (same time period as A); C) Krill size and weight in the whole water column during day time (11.43-12.25); and D) Krill size and weight in upper water layers at night (19.37-20.20)

3.3.2 Sprat

Pooling data from all sampling periods, sprat in the deeper layers (60-135 m) were significantly larger than more shallow-living (0-60 m) specimens (P<0,000) both day and night. When comparing day and night in depth resolved samples from the deep layer no significant difference were indicated, the same was true for depth resolved samples in the upper layer.

Although dependent on depth interval, Trawl catches gave significantly larger sprat in November (mean length 13, 00 cm) compared to December (mean length 10, 79 cm) (P<0,000, mw=<0,000), and December compared to January (mean length 9, 92 cm) (P<0,000, mw=<0,000). The same pattern was true for sprat weight (mean weight November; 15, 37 g; December; 9, 4 g; January; 6, 67 g). Since sizes increased by depth (see above and below) and more shallow sampling were carried out at the latter studies, this may be a depth effect as well as a time effect. By comparing sizes from the deepest intervals, however differences were found between cruises with larger sprat in November and smaller in January (P=0,000, 0,004).

November

No sprat was captured in the upper layers in November and only one individual was captured at 62-90 m (Fig. 14a&b, 17a&b), making a comparison of size by depth impossible.

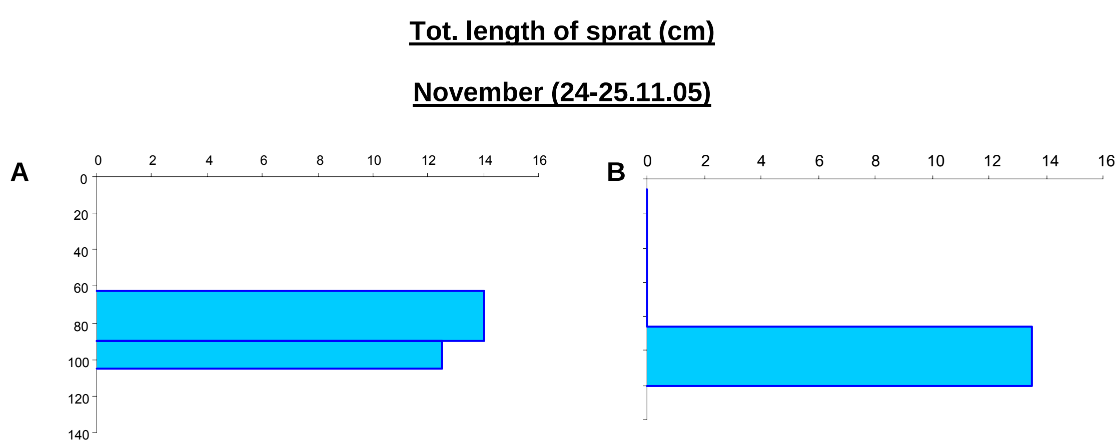


Fig. 14. Total length of sprat (*S. sprattus*) for A) 24.11.05 (12.55-13.29): and B) 25.11.05 (09.55-10.54)

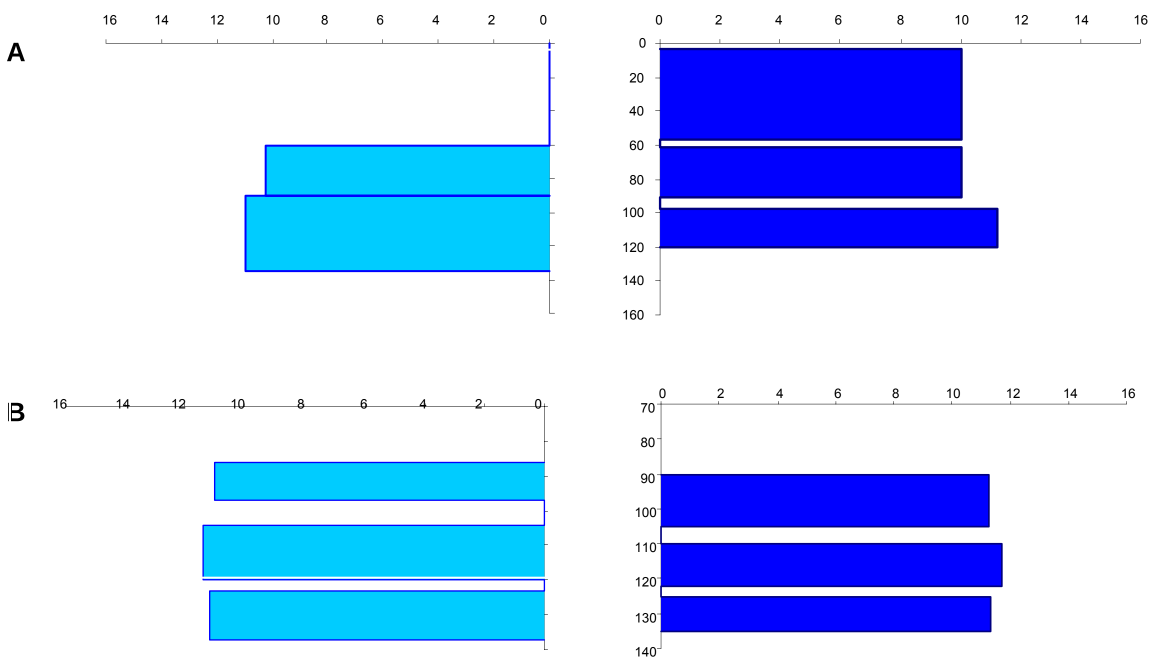
December

Sprat caught in the upper nets during the night differed significantly in size compared to those caught in the deeper net (98-120 m), with the larger sprat closer to the bottom (Fig. 15 & 18a).

At daytime in deeper water layers sprat length did vary significantly between 137-123 m (mean length 9,57 cm) and 120-104 m (mean length 11,43 cm) (P=0,001, mw=0,0005). Sprat weight, however, did not differ. There were no significant differences between the other depth intervals in sprat size during the day (15b & 18b).

There was a significant difference between sprat sizes in the upper layers at night and the deeper layers at night (P<0,000), with smaller sized sprat in the more shallow waters (Fig. 15b & c, 18b & c).

December (13.12.05)



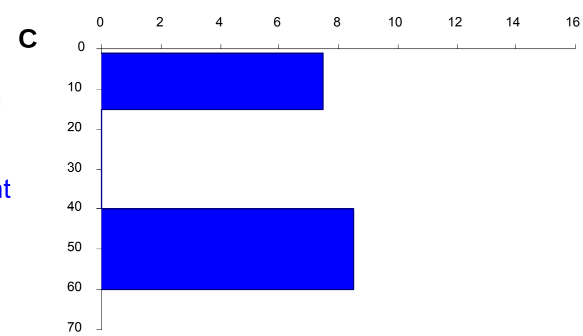


Fig. 15. Tot. length (cm) of sprat (*S. sprattus*) in pelagic trawl catch. A) Whole water column Day (11.43-12.25) and night (18.06-18.55); B) Deeper water layer. Day (14.13-14.47) and night (21.00-21.36); and C) Upper water layer. Night (19.37-20.20).

January

In January there was no significant difference in sprat size between the different layers during the day in fig. 16 a and 19 a. Night trawling did, however, show a significant difference in sprat length and weight between all the three layers with the larger sprat distributed closer to the bottom (Fig. 16 a & 19 a).
There was a significant difference between the day and night sprat weight at the deepest depths (134-96 m and 131-92 m) (P=0,036), with more heavy sprat at night (Fig. 16 a & 19 a).
When assessing the difference between all the mid water layers during the day with all the upper layers during the night from fig 16 and 19b & c we find that sprat sizes are significantly smaller in mid water during the day, except for Mann-Whitney test which do not show a difference in weight (P=0,002l/0,004mw, mw=0,0342l/0,1921).

Tot. length of sprat (cm)

January (4-5.01.06)

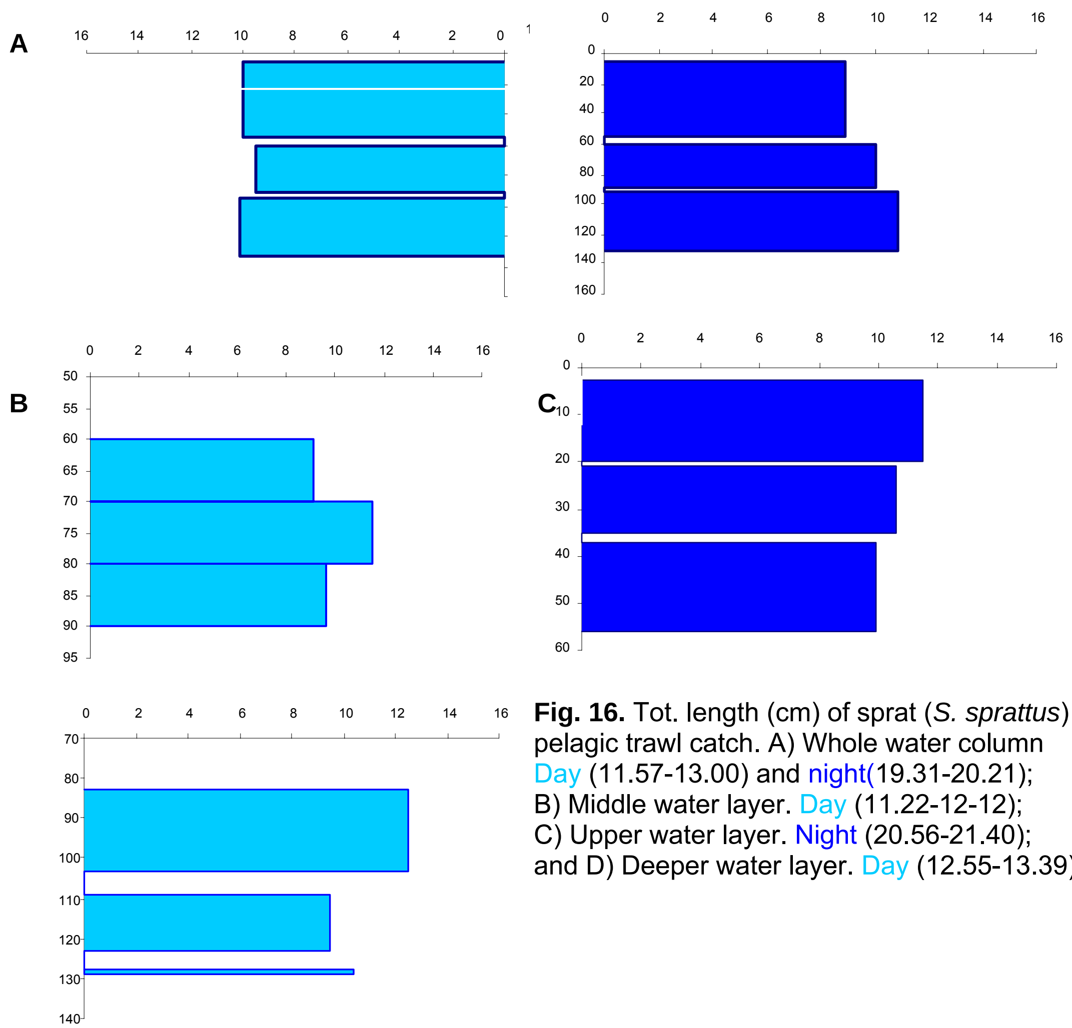


Fig. 16. Tot. length (cm) of sprat (*S. sprattus*) in pelagic trawl catch. A) Whole water column Day (11.57-13.00) and night(19.31-20.21); B) Middle water layer. Day (11.22-12-12); C) Upper water layer. Night (20.56-21.40); and D) Deeper water layer. Day (12.55-13.39)

Weight of sprat (g)

November (24-25.11.05)

A

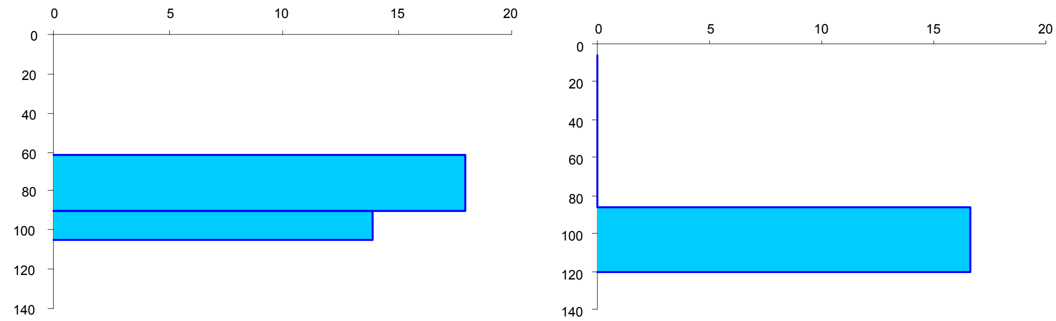
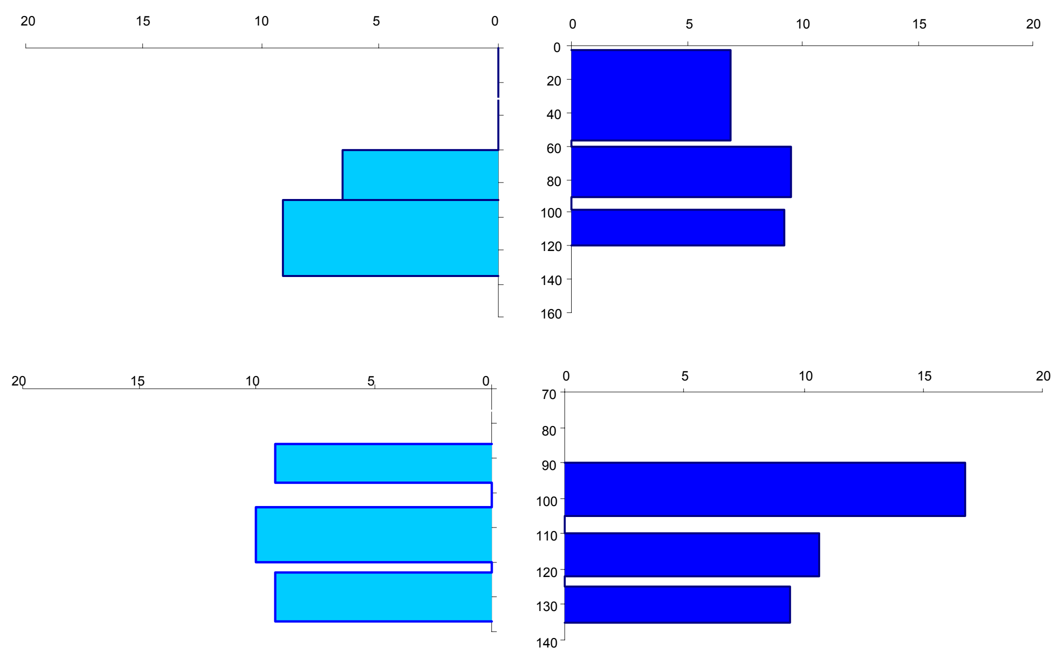


Fig. 17. Weight (g) of sprat (*S. sprattus*) for A) 24.11.05 (12.55-13.29): and B) 25.11.05 (09.55-10.54)

December (13.12.05)

A

B



C

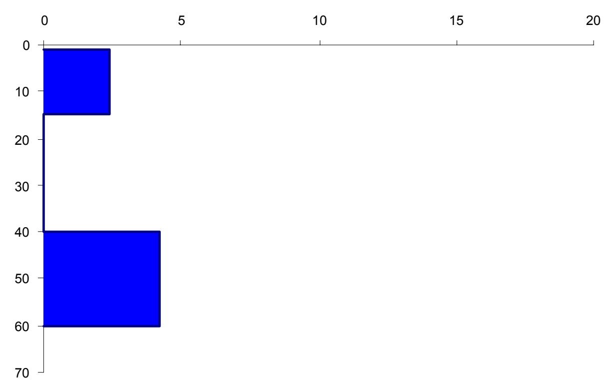


Fig. 18. Weight (g) of sprat (*S. sprattus*) in pelagic trawl catch. A) Whole water column Day (11.43-12.25) and night (18.06-18.55); B) Deeper water layer. Day (14.13-14.47) and night (21.00-21.36); and C) Upper water layer. Night (19.37-20.20)

Weight of sprat (g)

January (4-5.01.06)

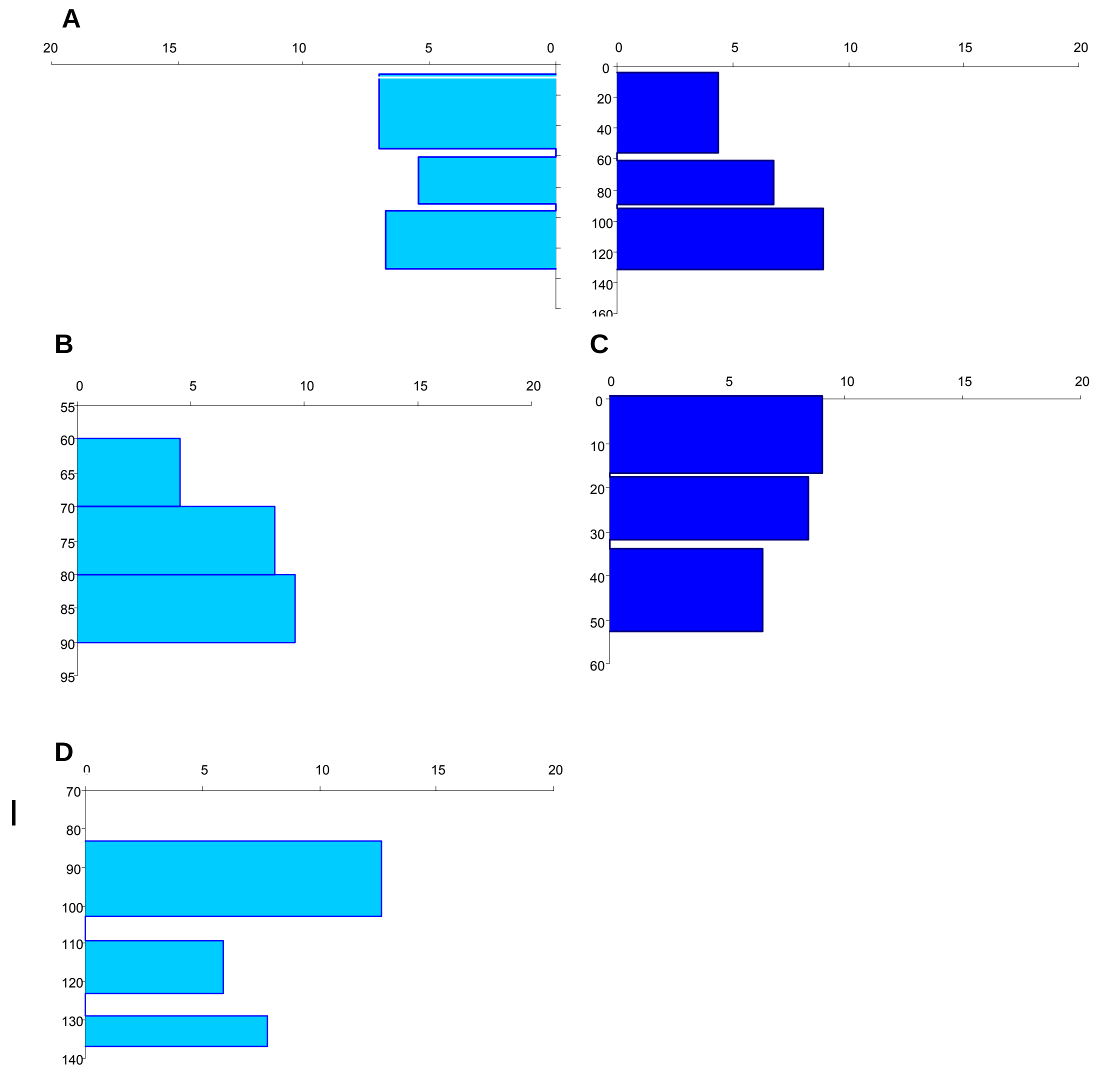


Fig. 19. Weight (g) of sprat (*S.sprattus*)in pelagic trawl catch. A) Whole water column. Day (11.57-13.00) and night (19.31-20.21); B) Middle water layer. Day (11.22-12-12); C) Upper water layer. Night (20.56-21.40); and D) Deeper water layer. Day (12.55-13.39)

3.3.3 Gadoids

Size distributions of whiting and haddock did not show any obvious patterns by depth (Table 2).

Depth (m)	Time	Mean Tot. Length (cm)	Mean Weight (g)
November			
62-90 (*)	13.17-13.29	43,50	907,0
58-86 (*)	10.17-10.36	48,00	1174,0
December			
In net opening	18.40-18.55	25,50	116,8
40-60	19.37-19.52	28,00	163,0
January			
146-153	12.19-13.00 (04.01.06)	34,00	293,0
61-91	20.06-20.21	29,00	197,0
4-56	20.56-21.11	28,25	166,5
37-56	21.12-21.26	33,75	431,0
80-90	11.22-11.43 (05.01.06)	30,90	239,3
128-137	12.55-13.07	33,25	307,0
83-103	13.28-13.39	27,00	169,0

Table 2. Mean total length (cm) and mean weight (g) of haddock (*), *Melanogrammus aeglefinus,* and of whiting, *Merlangius merlangus* in pelagic trawl catches.

3.4 Krill and fish feeding

3.4.1 Krill

Measurements of chlorophyll were carried out on 297 *M. norvegica*-stomachs, while 147 stomachs where examined microscopically for copepod prey.

Stomach fullness

Night stomach fullness were slightly, yet significantly higher in the upper layers (0-90 m) compared to deeper layers (90-135 m) (P=0,019, mw=0,0043) with a mean stomach fullness index of 2.62 for 0-90 m and 2.26 for 90-135 m. Day stomach fullness did not differ between these two strata (P=0,114, mw=0,0943).

There was no significant difference between day and night in stomach fullness in the deeper layer (P=0,233, mw=0, 2447). Krill caught at night from 90-135 m were significantly fuller than krill caught at 0-90 m at daytime (mean stomach fullness 1,76) (P=0,014, mw=0,0103), and krill in the upper layer at night did also have a fuller stomach in contrast to krill from 90-135 m (mean 2,08) during the day (P=0,001, mw=0,0003). Krill caught in the upper layers did show a higher stomach fullness index during the night than during the day (P, mw<0,000).

Total pigment analysis

The average total pigment in the krill gut was low for all the hauls. Highest values were found at night in the upper layers (Fig. 20c), with the greatest average value of 1, 4 ng·ind.$^{-1}$ from 1-15 m. The lowest values of total pigment were found in krill stomachs in deeper layers during the day (Fig. 20a & b), lowest average value were found from 104-120 m (0, 29 ng·ind.$^{-1}$). The low total values make a further analysis of patterns little meaningful.

Totalpigment (ng·ind.$^{-1}$) in krill stomachs (December)

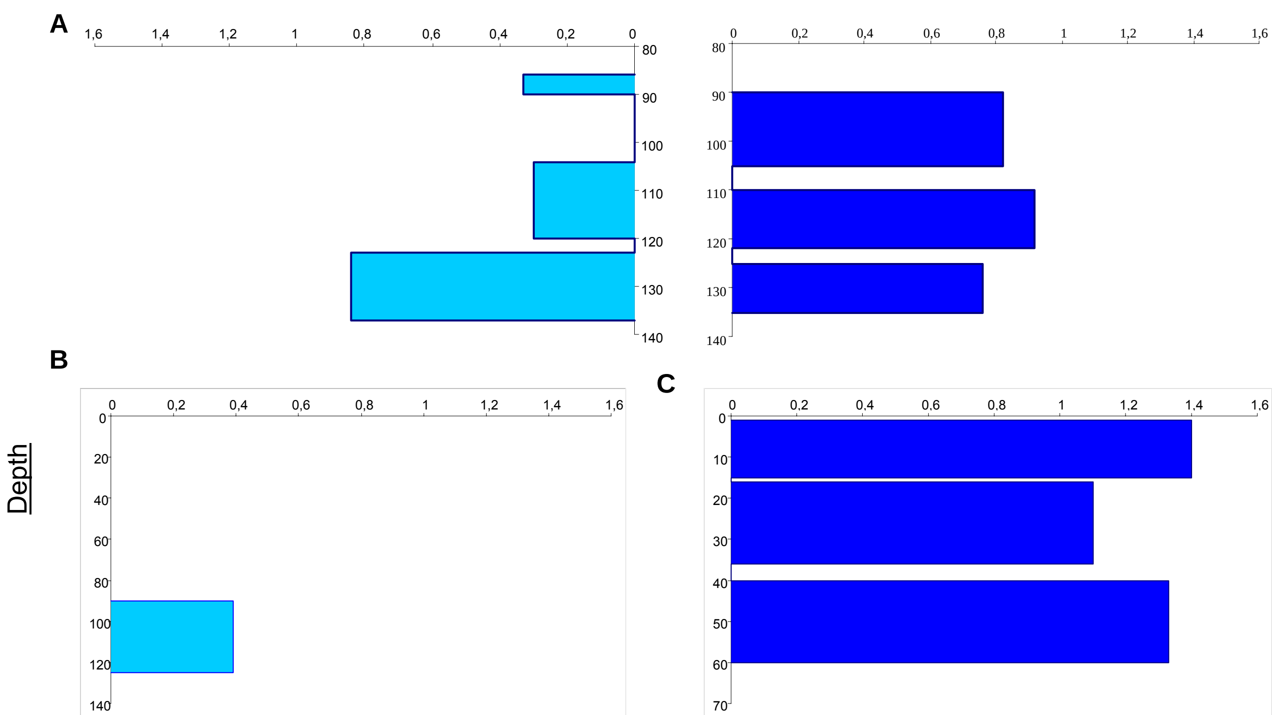


Fig. 20. The average of total amount of pigment (the sum of chlorophyll *a* and phaeopigment) in Krill at different depths in December. A) Deeper waters. Day (14.13-14.37) and night (21.00-21.36); B) Day (11.43-12.25); and C) Night. (19.37-20.20).

Prey

Of the 147 krill examined, 25% had copepod mandibles in their stomachs, and a higher percentage of mandibles in krill stomachs were found in krill from night trawl catch (Table 3a). Yet, there was no significant differences in the number of mandibles in krill stomachs between day and night (P=0, 34). No significant differences were found when comparing 90-135 m night with 90-135 m day (mw=0, 5040, P=0,648); 90-135 m night with 0-90 m day (mw=0, 1153, P=0,176); and 0-90 m day with 90-135 m day (mw=0, 2945, P=0,207) in the number of mandibles in krill stomachs (Table 3b)

A

	Number of krill examined	**Time**	**% of krill with mandibles in stomach**
	120	Day	23
December	30	Night	33
	150 (all)	Day+night	25

B

Depth (m)	**No. of mandibles found in krill stomachs**
0-60	7
60-90 m	11
90-135	10
123-137	18
90-105 (night)	18

Table 3. A) The % of mandibles found in krill (*M. norvegica)* examined during day and night; and B) The number of mandibles found in krill stomachs at the different depth intervals.

61 mandibles were found in the 147 *M. norvegica* examined. *Calanus spp* was the copepod most frequently eaten by krill. Approximately 40 % of all the copepods eaten were *Calanus spp*, followed by *Acartia,* 8 %, and *Temora, 7* %. Remaining identified copepods constituted only a small part of the krill diet. Even though *Oithona* was a dominating copepod species in the water column, it was hardly represented in the examined krill stomachs. 34% of the mandibles were not identified to genus. *Calanus spp* prevailed in stomachs of krill from two of the three tows from deeper layers (Fig. 21).

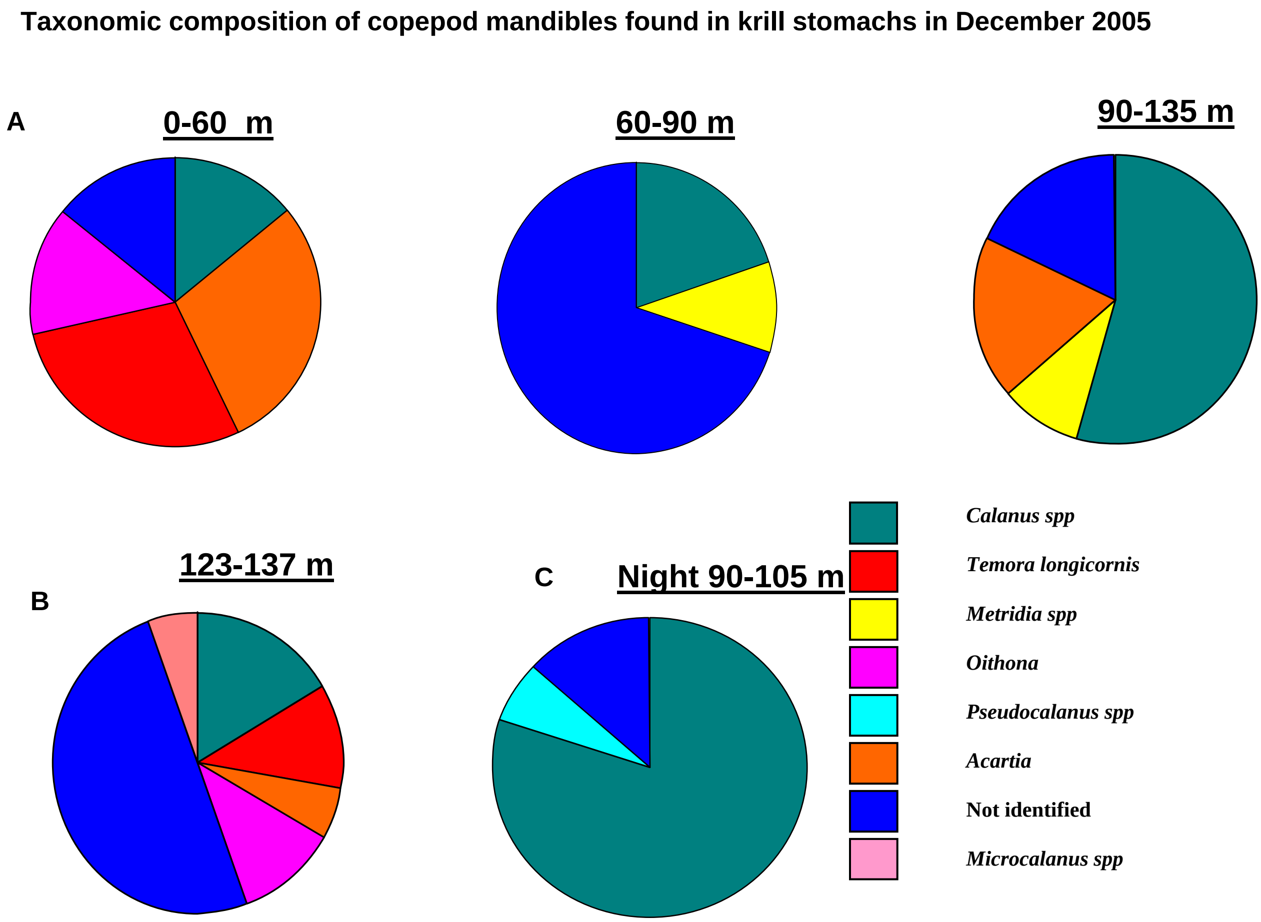


Fig. 21. Mandibles found in krill stomachs at different depths and at different time of day; A) 11.43-12.25; B) 14.13-14.24; and C) 21.00-21.11.

3.4.2 Sprat

Stomach analysis was conducted on 644 sprats.

Stomach fullness

To compare the stomach fullness of sprat three depth intervals were considered; 0-60 m; 60-90 m; 90-135 m.

November

Sprat in November did all have a stomach fullness index of 2, but gut content were only white “mush”, and were defined as empty of food contents (Rita Amundsen pers. comm.)

December

Stomach fullness did not show any significant difference between the depths during the day (P=0,626, mw=0,5026). Stomachs analysed from 60-90 m and 90-135 m had a mean stomach fullness of 2,11 and 2,05 respectively. The two deepest layers (90-135 m and 60-90 m; mean fullness of 1,98 and 2,07) did not indicate any difference in stomach fullness (P=0,212, mw=0,1816) during the night, however, they both did differ significantly from the upper layer (0-60 m; mean 3,11) (P/mw<0,000). Stomach fullness differed significantly between day and night in the deepest layer (P=0,041, mw=0,0187), with fuller stomachs during the night. In the middle layer there was not a difference between day and night (p=0,737, mw=0,4075). Stomachs were more full during the night at 0-60 m compared to the sprat stomachs examined in the deep (90-135 m) at daytime (P/mw<0,000). Moreover, day sprat stomach fullness were significantly lower than night stomach fullness (P=0,003, mw=0,0505).

January

Stomach fullness at night depths of 135-90 m (mean 2,03) and 90-60 m (mean 2,07) did not differ significantly from each other (P=0,562, mw=0,5702), neither did 90-60 m and 60-0 m in stomach fullness (P=0,269, mw=0,3377). Sprat stomachs from 60-0 m (mean 2,13), however, were significantly different from sprat stomach caught at 135-90 m (P=0,046) – though not right if I use mann whitney (0,1337). Sprat stomach fullness in the middle depth layer (90-60 m) did differ significantly between day and night, with more filled up stomachs during the day (P=0,003, mw=0,0220). There was no significant difference between day and night in stomach fullness when comparing all the fish collected in January independent of depths (P=0,758, mw=0,6031).

Stomach analysis

From the 644 sprat analysed 128, ca 20%, of the sprat had eaten.

All sprat stomachs were empty in November

In December, a high proportion of the sprat caught in upper layers at night had eaten (92% of the investigated specimen) (Fig. 22a). In contrast, less than 10 % of the individuals investigated from each of the deeper layers at night had food contents in their stomachs. Few sprats had food in stomach at daytime; 11% at 60-90 m and 15% at 90-135 m (Fig. 22a).

In January the majority of sprat with gut content was captured in the middle layer 60-90 m at daytime and in the upper layer during the night (Fig. 22b). Parallel to sprat in December little food was found in the middle layer at night. More food was found in the sprat catch from the bottom layer, especially during night (23%), in contrast to December (Fig. 22b). Taking all the three survey months (November, December and January) into account, the highest percentage of sprat with food content in the stomachs was at depth 60-90 m during the day (55%) and from 0-60 m during the night (43%)(Fig. 22c). Sprat did not eat during the day in the upper water layer, and only scarcely in the deepest depths (9%) (Fig. 22c).

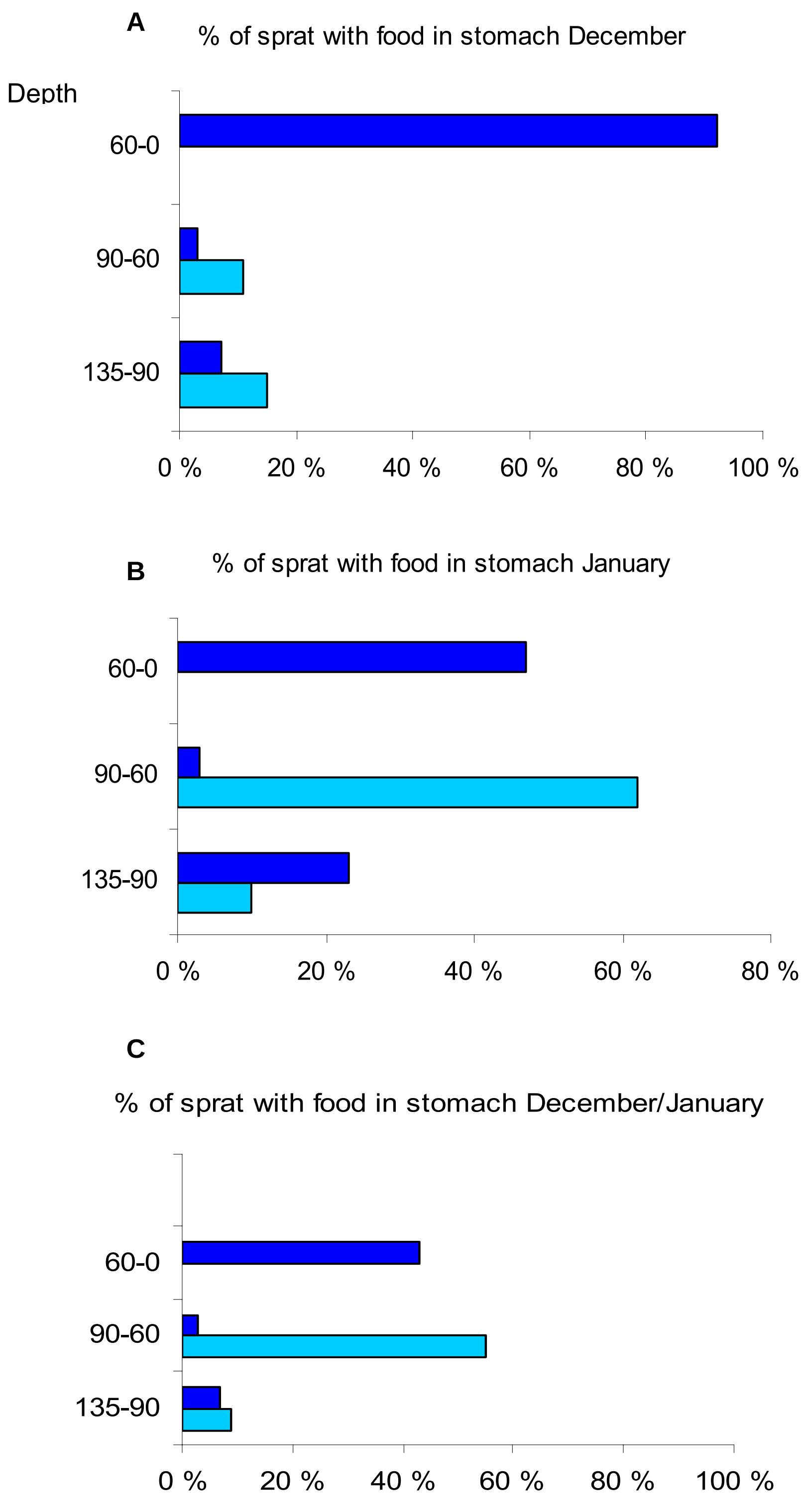


Fig. 22. The percentage of sprat containing food at different depths day and night; a) in December, b) in January, and c) for both December and January

Prey

Most of the food content consisted of copepods; mostly *Calanus spp* and *Acartia spp*. *Acartia* were mostly found in fish from the upper layers while *Calanus spp* were found in fish from the whole water column (Table 4).

DAY	December	January
Depth (m)		
135-90	*Calanus spp, copepods*	*Temora, calanus*
90-60	Grøt	*Calanus spp (*dominating*),* *euchetae*, copepods
60-0		
NIGHT		
135-90	*Acartia, calanus spp*	*Calanus spp*
90-60	*Calanus spp (*dominating*), acartia,* copepods	*Calanus spp*
60-0	*Acartia (*dominating*), euchetae, calanus spp, temora,* copepods	*Calanus, acartia, onchea, pilorm*, copepods

Table 4. Prey composition of sprat

Size distribution of sprat that had eaten

Sprat that had eaten in the upper layer were smaller than the sprat that had eaten in the deepest layer (P=0,000length, 0,004weight, mw=0,000, 0,000). This was also true for the sprat caught at daytime, where sprat that had eaten in the middle layer was significantly smaller than the ones in the deeper layer (P=0,001, 0,000, mw=0,002, 0,002). Sprat with food in the stomach at 60-90 m during the day were significantly larger than sprat in the upper layer at night (P=0, 001, 0,004, mw=0, 0004, 0, 0008), but was significant smaller in size compared to sprat in the bottom layer (P=0,004, 0,016, mw=0, 0004, 0, 0008). Sprat with food in stomach at 0-60 m at night was significant smaller than the fish caught at 90-135 m during the day (mw &P<0, 0000). There was no difference in size between day and night in the sprat that had food in the stomach in the deepest water layer (P=0, 82, 0,884, mw=1, 0,947).

Sprat that did eat was significantly smaller (mean 9, 38 cm, 5, 54 g) than sprat that did not eat (mean 10, 88 cm, 9, 4 g) (P, mw<0,000).

3.4.3 Gadoids

Stomach analyses were conducted on 3 haddock and 28 whiting. All fish examined had eaten. *M. norvegica* and *S. sprattus* were the most frequent prey, though other species occurred in low numbers. Fish in mid water during the day consumed the highest number of krill, and had the highest stomach fullness index. Gadoids caught in the deep had the lowest number of krill in their stomachs, and no sprat was consumed here (Table 5). Although low number in stomachs of gadoids, sprat were preyed upon in the upper layer at night, and in mid water during the day.

Depth (m)	**No. of gadoids examined**	**Mean stomach fullness**	**Mean no. of krill found in stomach**	**Mean no. of sprat found in stomach**
0-60	13 (Night)	3,2	2	0,2
60-90	15	3,4	6,1	0,2
90-130	3	2,7	0,7	

Table 5. Gadoid stomach fullness and contents

4. DISCUSSION

This study has addressed the vertical distribution of environmental variables and various taxa in the water column of Bunnefjorden during winter, with emphasis on diel vertical migrations. One distinct factor is probably not enough to explain diel vertical migrations of krill and fish. Factor such as physical aspects, prey distribution and abundance in the water column, and presence of predators could all contribute to vertical migrations of these organisms (Robinson 2003). These factors are analyzed in the following discussion.

4.1 Krill

4.1.1 Vertical distribution

The distribution of krill was studied both acoustically and by trawling. The trawl catches were not quantitative due to coarse meshes in the front of the trawl, and catches were low in relation to volume filtered. However, they served their purpose of identifying acoustic structures and providing a rough vertical distribution and samples for assessments of stomach contents.

The acoustic data suggested that krill during daytime were restricted to depths deeper than 75 m and 85 m in November and December respectively. In January, low abundance of krill made it difficult to establish their daytime distribution, but the net tows suggest concentrations deeper than 100 m. This may indicate a slightly deeper distribution compared to previous studies in Oslofjorden (Onsrud et al. 2004, Onsrud & Kaartvedt, 1998, Kaartvedt et al. 2002). In fjords at the western coast of Norway krill are normally restricted to layers deeper than 100 m (Giske et al. 1990, Balino & Aksnes 1993), possibliy due to clearer waters than in Oslofjorden (Onsrud & Kaartvedt 1998).

Temperature and salinity below sill depth were fairly homogenous by depth, and could not have any explanatory power for the vertical distribution of krill during the day, or the night distributions in deeper waters.

Minimum values of oxygen were 1, 48 ml l^{-1} at 50 m in November, 1, 28 ml l^{-1} at 150 m in December and the lowest values during the study were measured at 150 m in January (1, 02 ml l^{-1}). These vaules are close to minimum values that can be sustained for long periods by *M. norvegica*, although krill has been found in waters with oxygen as low as 0, 86 ml l^{-1} in Bunnefjorden (Fevolden 1974). In experiments where krill was caged at different depths in corresponding hypoxic waters of Gulmarfjorden, Sweden, Spicer et al. (1999) observed that krill would die if prevented from migrating to upper layers at night.

Krill vertical distribution is normally ascribed in terms of a trade-off between foraging and avoiding visually oriented predators, and krill stay deep at day to avoid visual predators (Tarling et al. 1988). The distribution and feeding of gadoids showed they represented a threat to krill inhabiting mid-water during daytime. Earlier studies from Oslofjorden show that krill are subjected to bottom-dwelling predators as well (Onsrud et al. 2004). With the Oslofjord being relatively shallow the krill may reach the bottom when migrating to avoid visual predators, and hence end up being closer to bottom dwelling predators. However, as the bottom waters of Bunnefjorden may be hypoxic for extended periods, there is not an established community of bottom-associated planktivorous fish in this fjord branch (Kaartvedt, personal communication).

Krill ascended almost all the way to the surface at dusk in November and December which coincide with Kaartvedt et al. (2002). Net tows in December and January showed a higher number in the upper 60 m, with the majority between 20-30 m. The same pattern was shown in Clyde Sea during winter (Lass et al. 2001). During the night however krill was also distributed in the deeper layers. The krill occupying these layers were larger. According to Tarling (1998) larger krill are more distributed in the deep and could be could be explained by the need of more energy to maintain a pelagic lifestyle.

Krill in upper layers during night were mostly distributed below the pycnocline, though some individuals did migrate through the pycnocline, suggesting that the physical gradients did not represent an important barrier. *M. norvegica* has in previous studies both appeared to migrate through the pycnocline and to cease the ascent below it (Onsrud & Kaartvedt 1998). Krill in Kattegat did not migrate into waters warmer than 14°C, and it has been shown that krill mortality increased at 15°C (Buchholz et al.1995). In my study, water above the pycnocline reached a maximum of 10, 7°C and could not be a reason for low number of krill close to the surface. Lowest salinity measurements of 22, 9 psu during the survey period were at 2 m in November, but increased rapidly in the upper few meters. In December and January the lowest salinity measurements experienced by krill were above 24, 7 psu in shallow waters, and below 10 m krill experienced salinity measurements from 31-33 psu. According to Forward and Fyhn, 1983, *M. norvegica* is well adapted to salinity measurements between 24 and 40 psu.

4.1.2 Vertical distribution and feeding

Nocturnal ascent would enhance access to algae, and though generally low, the greatest values of gut content were found in krill captured in the upper 0-15 m at night. These findings concur with previous observations, which connect herbivorous feeding of *M. norvegica* with nocturnal ascent to upper water layers during night (Onsrud & Kaartvedt 1998, Kaartvedt et al. 2002, Lass 2001). Yet, the highest concentrations of *M. norvegica* occurred from 20-30 m in both December and January. Higher predation risk in the upper layers, even at night, may affect the feeding excursion to the upper layer. The results showed that gadoids were indeed preying on krill at night. This may suggest an adaptive strategy where individuals move in and out of the most food rich upper layer and hence reduce predation risk because of the less time spent in the more predator hostile surface layer (Onsrud & Kaartvedt, 1998).

Previous studies elsewhere have shown that krill may cease the upward migration when chlorophyll concentrations are high enough to satisfy their algal need. Sameoto (1980) found that krill discontinued their vertical migration at 65 m where a phytoplanktonic rich layer appeared. However, this does not apply in my study, as chlorophyll *a* measurements were very low both in the water column and in the krill gut.

Carnivorous feeding may be important in vertical distribution of krill. *M. norvegica* is mainly characterized as a carnivore in northern waters (Kaartvedt et al. 2002). Copepod biomass was distributed through the water column, with the highest concentrations in the upper 20 m and in the lower 85 m. However, copepod biomass cannot explain the higher concentrations of krill from 20-30 m since copepod concentrations were at the lowest at this depth interval.

Mandibles were found in krill stomachs both day and night, including that of deep-living, overwintering Calanus. This indicates that although feeding rate may be higher at night, krill appear to forage on copepods during the day as well, and throughout the water column. Overwintering *Calanus* that became accumulated in deep water was a prevalent prey (see below). This is in accordance with Onsrud & Kaartvedt, 1998, who found that *M. norvegica* consumed overwintering copepods inhabiting deep waters both day and night. In Kattegat, krill feeding activity were constant day and night where copepod prey was evenly distributed through the water column (Lass et al. 2001), moreover Båmstedt and Karlson, 1998, proposed that krill did not show any diel feeding rhythm in their laboratory experiments.

Even though there were high concentrations of copepods, mainly over wintering *Calanus*, in the deep, krill did migrate to more shallow depths during the night. Sameoto, 1980, argued that *M. norvegica* could be dependent on a varied diet, this theory could be true for the krill migrating to the more algae rich 0-15 m, however not for krill in the layers below where chlorophyll concentrations were the same as in the deeper waters. Stomach gut content was significantly higher during the night. Feeding on phytoplankton (or copepods) makes krill less transparent and more vulnerable to visual predators, suggesting an advantage of feeding in the dark (Onsrud & Kaartvedt 1998, Tarling et al. 2000).

4.1.3 Selection of prey

Calanus dominated the gut contents of *M. norvegica* in Bunnefjorden, followed by *Acartia* and *Temora*. *Calanus* spp has been found to be the major prey organism of *M. norvegica* in many previous studies. In Balsfjord Sargent & Falk- Petersen indicated dominance of *Calanus* in the *M. norvegica* diet based on wax-ester analysis, and studies in the Oslo fjord concluded that *Calanus* were the dominant prey during winter (Kaartvedt et al. 2002).

The net tows from upper layers showed that *Acartia*, *Pseudocalanus* and *Oithona* prevailed, while *Calanus* dominated in the deeper layers. A very low number of krill were caught in the upper 0-60 m during the day, but the ones who were there were foraging on a mixed diet of *Acartia, Temora, Calanus, Oithona*, so that feeding reflected the copepod composition in the watercolumn. On the contrary *Temora* were not identified from the net samples, which may imply selective feeding on this taxon.

Antennae of *Temora* is continuously in motion and would increase the chance of being noticed by predators through hydrodynamic signals, moreover *Temora* appear in dense patches which coincide with the theory that krill locate these patches and stay there to forage (Goswami & Padmavati 1996, McClatchie 1985). This may explain why the WP2 net apparently failed to catch *T. longicornis* or that the subsample procedure made this species so scarce that it became overlooked in the samples. *M. norvegica* might selectively forage on this species since it has in previous studies appeared to show a slow reaction to mysid predators (Viitasalo 1998). *Temora* are more pigmented than the other copepods in these waters and would be easier to spot if *M. norvegica* use visual senses (Ohman 1988, Kaartvedt et al. 2002).

In the deeper water layers with the largest krill catches during the day, *Calanus* was the main prey item. However, copepods inhabiting the upper water layers were also found among the stomach contents from krill captured at depth. This suggests that copepods were eaten at the surface during night and the mandibles were retained in the krill stomach. Båmstedt & Karlsen, 1998 found that *M. norvegica* did not retain mandibles when copepod prey were continuously available to them, however mysids did retain mandibles up to 3 days when starved (Murtaugh 1984). In this case, copepods were abundant in the deeper layers during the day, and starvation causing mandible retention, if any, by *M. norvegica*, might occur because of an internal feeding rhythm, although experiments failed to demonstrate such rhythms in *M. norvegica* (Båmstedt & Båmstedt, 1998). Feeding at night might be an advantage due to the fact that the digestive tract becomes more apparent during feeding, or that swimming activity associated with feeding exposes the krill to predators. Mandibles in krill guts captured in deep waters at night were mainly from *Calanus*, suggesting they had been preyed upon here at night where *Calanus* was abundant.

4.2 Sprat

4.2.1 Vertical distribution

Sprat were hardly recorded acoustically in November due to low numbers, while the trawl catches suggest sprat were restricted to depths deeper than 90 m during the day. In December and January most sprat were recorded below 130 m at day time. This is deeper than most previous studies in the same locality (Røstad 2006). Bunnefjorden normally is devoid of sprat in the deeper part of the basin due to hypoxic/anoxic conditions. The oxygen values the winter of 2005/2006 (minima from 1.02 – 1.48 ml l^{-1}) were sufficiently high to sustain sprat throughout the water column. Previous studies in the inner Oslofjord indicate that while gadoids in general stayed in waters with oxygen contents above ~1-1,5 ml l^{-1} , sprat were tolerable to oxygen levels as low as 0,5 ml l^{-1} (Kaartvedt et al. 2006- manuscript). It has been proposed that sprat use the inner Oslofjord as a refuge for their gadoid predators during winter. In the case of this study, oxygen levels were just at the limit for gadoids to be able to exploit sprat in deep water. Yet, selection of deep, dark waters for overwintering likely can be ascribed to predator avoidance. The distribution and stomach contents of gadoids suggest that the highest predation risk occurred in the middle and upper water layer day and night.

4.2.2 Vertical distribution and feeding

Sprat ascended at night forming a layer in mid waters. Trawling suggested that the majority of the sprat occurred below 60 m, however sprat were also caught in the very upper layer in December, and from 40-60 m for both December and January.

Sprat feeding intensity decreased with increasing sprat size and depth, in accordance with studies by Szypula 1992. It also varied by time of day. In December, stomach fullness of sprat was higher during the night in both the upper and deepest layer. In January, on the other hand, the highest gut content and abundance of copepods was recorded from sprat captured in the middle layer during the day. It appears that sprat that were foraging on copepods in the upper layer were smaller than the sprat foraging in the deeper layers. Sprat foraging on prey in the middle layer was in between the two different size groups. Sprat that had eaten were in general smaller than sprat that did not eat, suggesting that small sprat need more energy to survive and maybe take higher risks to reach maturity faster and hence prioritized feeding during winter. Sprat is a visual feeder and this might be the reason why sprat migrates to the upper layers at night to feed and in the middle layer during the day where light intensity probably is more optimal to detect its prey.

4.2.3 Selection of prey

Sprat did in general forage on copepods, which coincide with previous studies (Szypula 1992, Cardinale et al. 2003, Kaartvedt et al. 2006). Stomach contents of sprat foraging on copepods in the upper layers at night were most varied compared to the other depths, although *Acartia* and *Calanus* dominated. In the deeper layers *Calanus* dominated both in net samples and in sprat stomachs. *Oithona* and *Pseudocalanus* were not represented even though occurring in high abundance in the water column and have been identified as prey for sprat in previous winter-studies in Bunnefjorden (Kaartvedt et al, 2006). *Oithona* is a small, rather inactive cyclopoid copepod (Gonzales and Smetacek, 1994), and may be less suitable as prey or hard to detect because of its small size. *Acartia* prevailed in sprat stomachs of the upper water layers at night. In accordance with results from the net tows, *Acartia* is mainly a surface dweller (Hansson et al. 1990, Møllmann and Køster, 2002) hence primarily being preyed on in the surface layer. The lower abundance of *Acartia* in sprat stomachs in January may reflect its lower abundance later in winter. The prevalence of *Calanus* among the stomach contents from sprat in deep water could indicate a non-selective behavior, that sprat forage on the prey that is available. Yet, sprat are know to be a visual feeder (Cardinale, et al. 2003) and *Calanus* may be easier spotted compared with most copepods due to its larger size.

4.3 Gadoids

Gadoids were located in mid- and deep waters during the day, and in the upper 60 m during the night.

Haddock were only caught in November, when trawling were only conducted during the day. Haddock were found from 60-90 m, krill being a major prey item. However, benthic invertebrates were also found in haddock stomachs, suggesting feeding at the bottom as well. Adult haddock often has a demersal lifestyle, and benthic invertebrates are an important part of their diet (Hedger et al. 2004). In the course of their life, euphausiids, according to Cranmer, 1986, become a smaller part of their diet, and larger haddock become more dependent of fish in their diet. Other studies show that crustaceans are among the main food item of haddock independent of age and size (Jiang & jørgensen 1996). Haddock in this particular study were adults (>30 cm) (Hedger et al. 2004), though sprat were not identified in the stomach contents among the few investigated specimen.

Whiting were caught in December and January. Whiting were distributed in the upper 0-60 m at night, and deeper during the day, with an apparent maximum from 80-100 m. Whiting was mainly preying on krill, though a few sprat were eaten as well and may represent important prey due to their large size. Sprat seemed to be eaten in the upper part of the water column both day and night. No systematic trend was apparent for the state of digestion during day and night, hence no diel feeding pattern could be shown for whiting foraging on sprat. No diel pattern of whiting foraging on sprat was found in the North Sea either, according to Rindorf 2003. According to Hislop et al. 1991, larger whiting eat larger prey, this was not the case in this study as there were no particular difference in size of the whiting foraging on sprat compared to those foraging on the smaller euphausiids.

Krill was the main (numerical dominant) food item of whiting, which coincide with previous studies in these waters (Onsrud et al. 2004). They were associated with the krill layer both day and night. The trawl catches suggest that whiting appeared to be distributed mostly in the upper part of the krill layer during the day. At night whiting were caught in the upper waters concurrent with the highest abundance of krill. This suggests that the gadoid vertical migrations are governed by the movement of their prey, which is proposed by Marshall 1979.

Highest abundance of krill in the gadoid guts where in the midwater during the day, while the lowest feeding was suggested in the deep, although krill was most abundant at these depths during the day. This pattern could be due to the necessity of vision to capture krill. Whiting has relatively large eyes (Aksnes & Giske 1993), and may be able to forage in the upper part of the krill layer during the day (Onsrud & Kaartvedt 1998). Deeper down, however, light levels may not be sufficient for efficient feeding. Whiting appeared to forage on krill in the upper layers during the night. The fresh state of digestion implies that food was eaten recently. Krill is a large and active zooplankton organism (Ohman 1988), and it may be possible that whiting was able to detect its prey by vision in the upper layers. Another possibility would be detection of prey by the mechanosensory lateral line system when light levels are low (Janssen et al. 1995).

In conclusion, gadoids in this study were foraging on krill during both day and night in Bunnefjorden. The abundance of krill in gadoid stomachs were higher at daytime, however the state of digestion of krill in whiting stomach at night did show that they had been eaten recently. Hence no diel feeding pattern could be found. The diel vertical migration of gadoids in this study is most likely explained by concurrent movements of their prey.

4.4 Summary

Physical factors such as temperature and salinity do not seem to have affected vertical migrations of krill and fish in this study. Oxygen content in the water column could prevent gadoid from reaching deeper waters, and hence the deep could function as refuge for krill and sprat from predators. The most probable cause for vertical migrations for krill and sprat would be a trade-off of optimizing food intake and to avoid visual predators. Gadoid vertical migrations feeding would be related to the distribution of their prey in the water column and their ability to detect the prey visually. Krill and sprat feeding was related to prey abundance, and maybe prey size and movements, which will affect both detectability and prey avoidance reactions.

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APPENDIX

Cruise Bunnefjorden November 2005 – January 2006

		Depth (m)	Time
24 November 2005			
Haul 1			
	→	105-90	12.55-13.11
	→	90-62	13.17-13.29
25 November 2005			
Haul 1			
	→	120-86	09.55-10.17
	→	86-58	10.17-10.36
	→	56-6	10.37-10.54
13 December 2005			
Haul 1			
	→	135-95	11.43-12.04
	→	90-60	12.05-12.13
	→	60-0	12.14-12.25
Haul 2			
	→	137-123	14.13-14.24
	→	120-104	14.24-14.34
	→	97-86	14.35-14.47
Haul 3			
	→	120-98	18.06-18.24
	→	90-61	18.24-18.38
	→	57-3	18.40-18.55
Haul 4			
	→	60-40	19.37-19.52
	→	34-16	19.54-20.01
	→	15-1	20.02-20.20
Haul 5			
	→	125-127 (nede til 135)	21.00-21.11
	→	122-110	21.15-21.25
	→	105-90	21.26-21.36
19 December 2005			
Haul 1			
	→	153	day
Haul 2			
	→	153-146	day
4 January 2006			
Haul 1			
	→	134-96	11.57-12.16
	→	91-61	12.19-12.36
	→	55-6	12.38-13.00
Haul 2			
	→	131-92	19.31-19.47
	→	89-60.5	19.48-20.03
	→	56-4	20.06-20.21
Haul 3			
	→	56-37	20.56-21.11
	→	35-21	21.12-21.26
	→	20-2,5	21.27-21.40
5 January 2006			
Haul 1			
	→	90-80	11.22-11.43
	→	80-70	11.44-11-55
	→	70-60	11.56-12.12
Haul 2			
	→	128-129	12.55-13.07
	→	123-109	13.12-13.25
	→	103-83	13.28-13.39

APPENDIX 2 **13.12.05** **Bunnefjorden**

Haul 1	60-0 m			Haul 1	90-60 m		
Krill	**Length (cm)**	**Weight (g)**	**Stomach fullness**	**Krill**	**Length (cm)**	**Weight (g)**	**Stomach fullness**
1	3,5	0,3168	0	1	3,2	0,2068	2
2	3,6	0,2961	1	2	3,5	0,2789	2
3	3,6	0,3286	1	3	3,4	0,284	4
4	3,6	0,3329	3	4	3,3	0,2567	0
5	3	0,2545	3	5	3,4	0,2944	1
6	3,7	0,3443	1	6	3,6	0,3158	1
7	3,1	0,2723	1	7	3,4	0,258	4
8	3,4	0,3027	1	8	3,5	0,3249	3
9	3,5	0,3593	2	9	3,2	0,2838	2
10	2,2	0,1042	0	10	3,4	0,2864	0
11	3,4	0,2748	2	11	3,5	0,2918	3
12	3,4	0,315	1	12	3,7	0,3612	3
13	2,3	0,1045	0	13	3,5	0,3718	1
14	3,3	0,3293	1	14	3,6	0,3316	3
15	3,1	0,2812	0	15	2	0,0541	2
16	3,2	0,2712	0	16	3,6	0,3784	4
17	3,3	0,2794	3	17	3,4	0,2821	0
18	3,1	0,2816	4	18	3,7	0,4159	2
19	3,4	0,327	4	19	3	0,2112	0
20	3,3	0,3425	1	20	2,7	0,0913	3
21	3,5	0,2893	3	21	3,6	0,2787	1
22	3,3	0,3192	1	22	3,5	0,3319	4
23	3,4	0,2906	1	23	3,4	0,2659	2
24	3,4	0,2751	0	24	3,5	0,3285	3
25	3,6	0,3344	1	25	3,5	0,2584	4
26	3,3	0,2819	1	26	3,5	0,3005	2
27	3,4	0,3046	3	27	3,2	0,2474	2
28	3,4	0,3015	1	28	3,5	0,3223	2
29	3,2	0,2726	1	29	3,5	0,3317	1
30	2,4	0,0897		30	3,3	0,2523	2
Average	3,26	0,28	1,4	Average	3,37	0,28	2,1

Haul 1	135-90 m		
Krill			
1	3,7	0,394	3
2	3,5	0,2504	1
3	3,6	0,3302	3
4	3,4	0,2332	3
5	3,6	0,2942	1
6	3,4	0,2408	3
7	3,6	0,2752	3
8	3,4	0,2756	4
9	3,6	0,2551	1
10	3,6	0,3309	3
11	3,5	0,3534	3
12	3,4	0,2662	4
13	3,5	0,3293	4
14	3,6	0,2807	4
15	3,2	0,2553	2
16	3,4	0,3166	4
17	3,4	0,2361	1
18	3,1	0,2452	1
19	3,5	0,3118	3
20	3,4	0,2894	1
21	3,5	0,2815	2
22	3,3	0,2913	4
23	3,2	0,2635	1
24	3,4	0,2859	3
25	2,9	0,2496	0
26	3,6	0,3491	1
27	3,5	0,3083	1
28			
29			
30			
Average	3,44	0,29	2,4

Haul 2	137-123 m		
Krill			
1	3,9	0,245	2
2	3,6	0,2971	3
3	3,5	0,3029	4
4	3,5	0,3196	2
5	3,4	0,3044	3
6	3,5	0,3518	1
7	3,4	0,3123	2
8	3,3	0,311	3
9	3,6	0,3235	2
10	3,6	0,2884	1
11	3,5	0,2402	1
12	3,6	0,2798	4
13	3,4	0,2859	3
14	2,6	0,1138	1
15	2,2	0,1009	4
16	3,5	0,2824	2
17	3,1	0,2569	2
18	3,4	0,3001	2
19	3,6	0,3845	3
20	3,5	0,3042	0
21	3,2	0,3437	0
22	3,5	0,2433	2
23	3,6	0,3054	2
24	3,6	0,2866	3
25	3,4	0,2733	3
26	3,5	0,2811	3
27	3,8	0,3983	2
28	3,5	0,2823	4
29	3,2	0,3322	3
30	3,5	0,2936	
Average	3,41	0,29	2,3

Haul 2	120-104			Haul 2	97-86		
Krill				Krill			
1	3,6	0,3768	4	1	3,5	0,3494	1
2	3,3	0,2965	3	2	3,5	0,2818	2
3	3,5	0,3586	3	3	3,6	0,3142	3
4	3,5	0,3354	2	4	3,4	0,3235	1
5	3,4	0,3475	1	5	3,6	0,3219	1
6	3,6	0,3986	2	6	3,9	0,3862	4
7	3,4	0,2993	0	7	3,8	0,3572	1
8	3,6	0,4253	2	8	3,4	0,3052	2
9	3,3	0,2927	1	9	3,5	0,2995	1
10	3,5	0,3246	1	10	3,5	0,3435	1
11	3,3	0,2919	0	11	3,4	0,2849	1
12	3,5	0,3029	3	12	3,5	0,306	2
13	3,6	0,3428	1	13	3,4	0,3135	2
14	3,4	0,2935	1	14	3,5	0,3308	4
15	3,3	0,2837	3	15	3,6	0,3173	1
16	3,3	0,3206	1	16	3,8	0,3797	0
17	3,7	0,3411	1	17	3,7	0,423	2
18	3,5	0,3109	2	18	2,5	0,096	0
19	3,6	0,3796	2	19	3,5	0,3158	2
20	3,2	0,2682	2	20	3,5	0,3106	3
21	3,9	0,4649	1	21	3,8	0,4296	2
22	3,8	0,4325	4	22	3,9	0,3532	2
23	3,6	0,3374	2	23	3,6	0,3369	1
24	3,4	0,3233	1	24	3,3	0,2713	3
25	3,5	0,334	2	25	3,5	0,2747	3
26	3,5	0,3208	1	26	3,4	0,3035	2
27	3,4	0,3076	1	27	3,9	0,3498	4
28	3,7	0,3746	3	28	3,3	0,3166	2
29	3,8	0,487	2	29	3,6	0,3579	1
30	3,7	0,3583	3	30	3,4	0,2649	1
Average	3,51	0,34	1,8	Average	3,53	0,32	1,8

Haul 4	34-16 m			Haul 4	15-1 m		
Krill				Krill			
1	3,3	0,2126	2	1	3,5	0,3005	3
2	3,2	0,2904	3	2	3,3	0,2345	4
3	3,2	0,2382	2	3	3,3	0,2409	3
4	2,6	0,1118	2	4	3,6	0,2929	0
5	3,4	0,3156	3	5	3,7	0,2898	3
6	3,2	0,2323	1	6	3,1	0,19	3
7	3	0,1871	2	7	3,5	0,293	3
8	3,5	0,2155	1	8	3,5	0,2512	4
9	3,4	0,2995	4	9	3,5	0,273	3
10	3,3	0,2829	3	10	3,2	0,2379	3
11	3,6	0,2745	1	11	3,3	0,2984	3
12	3,5	0,2871	1	12	3,2	0,2421	3
13	3,5	0,2705	3	13	3,2	0,3039	1
14	3,4	0,2757	3	14	3,6	0,3997	1
15	3,3	0,2532	2	15	3,2	0,242	3
16	3	0,2224	1	16	3,5	0,3092	3
17	3,6	0,3006	3	17	4	0,3973	3
18	3,6	0,311	3	18	3,7	0,36	0
19	3,3	0,2759	3	19	3,6	0,3414	3
20	3,2	0,2757	0	20	3,5	0,3381	2
21	3,4	0,2765	3	21	3,6	0,3052	3
22	3,4	0,2433	0	22	1,9	0,0427	4
23	3,4	0,275	3	23	3,7	0,303	3
24	3,2	0,2523	4	24	3,5	0,285	2
25	3,3	0,2623	3	25	3,2	0,2383	3
26	3,3	0,2429	3	26	3,4	0,2875	2
27	3,4	0,2815	2	27	3,4	0,2721	3
28	3,3	0,2905	2	28	3,5	0,3231	2
29	3,7	0,2956	1	29	3,3	0,3275	1
30	3,3	0,2314	0	30	3,1	0,2373	3
Average	3,33	0,26	2,1	Average	3,40	0,28	2,6

Haul 4	60-40 m			Haul 5	122-110			
1	3,3	0,2505	3		1	3,7	0,3195	1
2	3,4	0,2841	3		2	3,6	0,2476	1
3	3,3	0,2321	4		3	3,3	0,2961	3
4	3,5	0,3571	3		4	3,4	0,2581	3
5	3,1	0,245	2		5	3,5	0,3499	2
6	3,4	0,2523	3		6	3,7	0,1968	2
7	3,2	0,2363	3		7	3,5	0,3215	3
8	2,3	0,0857	4		8	3,6	0,3097	2
9	2,2	0,0654	4		9	3,3	0,2028	2
10	3,2	0,2519	2		10	3,1	0,2023	1
11	3,5	0,3004	3		11	2	0,0543	1
12	3,4	0,3444	3		12	3,2	0,2762	3
13	2,4	0,081	4		13	3,2	0,23	4
14	3,3	0,303	1		14	3,8	0,3597	3
15	3	0,2915	3		15	3,5	0,2881	4
16	3	0,2638	3		16	2,7	0,1728	4
17	3,3	0,2766	4		17	3,7	0,3096	3
18	3,2	0,2773	3		18	3,5	0,2701	3
19	2,3	0,0775	4		19	3,5	0,3036	0
20	3,1	0,283	3		20	3,4	0,3086	3
21	3,5	0,3155	3		21	3,4	0,2804	2
22	3,2	0,2672	3		22	3,3	0,2375	2
23	2,5	0,1398	3		23	3,8	0,3519	3
24	3,5	0,265	3		24	3,7	0,2735	3
25	3,4	0,2763	4		25	3,4	0,222	1
26	3,5	0,2872	4		26	3,3	0,1239	1
27	3,4	0,3052	4		27	3,5	0,3521	2
28	3,1	0,2227	3		28	3,4	0,2541	1
29	3,7	0,3471	3		29	3,5	0,2339	2
30	3,5	0,3403			30	3,6	0,252	4
Average	3,14	0,25	3,2	Average		3,40	0,26	2,3

Haul 5	125-127 m		
1	3,40	0,3459	2
2	3,60	0,3373	3
3	3,60	0,3675	2
4	3,70	0,4130	1
5	3,40	0,3538	3
6	3,60	0,4237	1
7	3,40	0,2574	1
8	3,50	0,3200	3
9	3,20	0,3399	2
10	3,40	0,2197	1
11	3,40	0,3305	4
12	3,10	0,2811	1
13	3,40	0,3409	2
14	3,90	0,3614	2
15	3,30	0,3238	1
16	3,60	0,3725	4
17	3,40	0,3515	4
18	3,80	0,4463	2
19	3,30	0,3190	2
20	3,30	0,3589	2
21	3,40	0,2127	3
22	3,50	0,2328	1
23	3,40	0,2168	2
24	3,60	0,2883	2
25	3,40	0,2230	1
26	4,00	0,4193	3
27	3,40	0,3411	1
28	3,70	0,4242	3
29	3,60	0,4272	4
30	3,40	0,3269	3
Average	3,49	0,33	2,2

Haul 5	105-90 m		
1	3,20	0,2703	3
2	3,50	0,2744	3
3	3,50	0,2688	3
4	3,30	0,2366	2
5	3,40	0,2929	2
6	3,40	0,3321	2
7	3,30	0,3045	1
8	3,20	0,2942	2
9	3,50	0,3059	1
10	2,90	0,2492	2
11	3,50	0,3149	4
12	3,20	0,2476	2
13	3,40	0,2739	2
14	3,70	0,2606	2
15	3,80	0,2882	1
16	3,80	0,3995	3
17	3,10	0,2821	4
18	3,80	0,2794	1
19	2,80	0,1413	2
20	2,00	0,0384	1
21	3,40	0,2270	2
22	3,40	0,2585	2
23	3,20	0,2398	3
24	3,60	0,2701	4
25	3,70	0,3406	2
26	2,40	0,0804	3
27	3,40	0,3493	3
28	3,30	0,3114	2
29	3,50	0,3108	2
30	3,40	0,3190	2
Average	3,32	0,27	2,3

APPENDIX 3 **13.12.2005** **Stomach pigment**

	Krill	Rf (før syre) fluorescens	Re (ettersyre) fluorescens	total amount pr/ organism	chloropyll *a* pr /organsim	paeo-pigment pr/organsim
Haul 1 125-90 m	1	0,3	0	0,159	0,186	-0,027
	2	0	-0,4	0	0,248	-0,248
	3	0,6	0,1	0,318	0,310	0,008
	4	1,6	0,9	0,848	0,434	0,414
	5	0,5	0,3	0,265	0,124	0,141
	6	0,4	0	0,212	0,248	-0,036
	7	1,2	0,7	0,636	0,310	0,326
	8	0,6	0,3	0,318	0,186	0,132
	9	-0,2	-0,3	-0,106	0,062	-0,168
	10	0,4	0,1	0,212	0,186	0,026
	11	0,6	0,4	0,318	0,124	0,194
	12	2,6	1,8	1,378	0,496	0,882
	13	0,1	0	0,053	0,062	-0,009
	14	1,9	1,5	1,007	0,248	0,759
	15	0,7	0,3	0,371	0,248	0,123
	16	1,1	0,5	0,583	0,372	0,211
	17	0,6	0,2	0,318	0,248	0,070
	18	0	-0,2	0	0,124	-0,124
	19	0,9	0,6	0,477	0,186	0,291
	20	0,3	0	0,159	0,186	-0,027
	21	0,5	0,2	0,265	0,186	0,079
	22	1,1	0,6	0,583	0,310	0,273
	23	0	0	0	0,000	0,000
	24	3,6	3	1,908	0,372	1,536
	25	0	-0,1	0	0,062	-0,062
	26	0,2	0	0,106	0,124	-0,018
	27	0,4	0,1	0,212	0,186	0,026
Average				**0,39**		

Haul 2 137-123 m

1	0,6	0,2	0,318	0,248	0,070
2	0,4	0,1	0,212	0,186	0,026
3	6,7	5,3	3,551	0,868	2,683
4	0,5	0,4	0,265	0,062	0,203
5	3,8	3,1	2,014	0,434	1,580
6	0	0,1	0	-0,062	0,062
7	0,3	0,1	0,159	0,124	0,035
8	4	3,1	2,12	0,558	1,562
9	0,6	0,5	0,318	0,062	0,256
10	0,1	0	0,053	0,062	-0,009
11	-0,2	-0,4	-0,106	0,124	-0,230
12	2	1,4	1,06	0,372	0,688
13	0,8	0,5	0,424	0,186	0,238
14	-0,2	-0,2	-0,106	0,000	-0,106
15	1	0,9	0,53	0,062	0,468
16	0,4	0,4	0,212	0,000	0,212
17	0	0	0	0,000	0,000
18	0,4	0,2	0,212	0,124	0,088
19	1,5	1,1	0,795	0,248	0,547
20	-0,1	-0,3	-0,053	0,124	-0,177
21	-0,3	-0,2	-0,159	-0,062	-0,097
22	0,8	0,5	0,424	0,186	0,238
23	1,2	1	0,636	0,124	0,512
24	2	1,7	1,06	0,186	0,874
25	3,3	2,7	1,749	0,372	1,377
26	0,2	0	0,106	0,124	-0,018
27	0,1	0	0,053	0,062	-0,009
28	2,2	1,7	1,166	0,310	0,856
29	0	0	0	0,000	0,000
30	0	0	0	0,000	0,000
Average			0,48		

Haul 2

1	0,8	0,6	0,424	0,124	0,300
2	1,3	1	0,689	0,186	0,503
3	0,6	0,3	0,318	0,186	0,132
4	0,3	0,2	0,159	0,062	0,097
5	0,4	0,1	0,212	0,186	0,026
6	0,3	0	0,159	0,186	-0,027
7	-0,3	-0,2	-0,159	-0,062	-0,097
8	1	0,8	0,53	0,124	0,406
9	0,2	0	0,106	0,124	-0,018
10	0	0,2	0	-0,124	0,124
11	0	0	0	0,000	0,000
12	0,9	0,6	0,477	0,186	0,291
13	0	0	0	0,000	0,000
14	0,1	0,1	0,053	0,000	0,053
15	1	1	0,53	0,000	0,530
16	0,4	0,3	0,212	0,062	0,150
17	1,7	1,6	0,901	0,062	0,839
18	0,4	0,6	0,212	-0,124	0,336
19	1,7	1,2	0,901	0,310	0,591
20	0,5	0,3	0,265	0,124	0,141
21	0,5	0,3	0,265	0,124	0,141
22	0,7	0,3	0,371	0,248	0,123
23	0,1	0	0,053	0,062	-0,009
24	0,4	0,2	0,212	0,124	0,088
25	0,3	0,1	0,159	0,124	0,035
26	0,3	0	0,159	0,186	-0,027
27	-0,1	-0,2	-0,053	0,062	-0,115
28	0,4	0,2	0,212	0,124	0,088
29	2,1	1,1	1,113	0,620	0,493
30	0,8	0,6	0,424	0,124	0,300
Average			0,28		

Haul 2

	1	0	-2	0	1,240	-1,240
	2	0,1	0	0,053	0,062	-0,009
	3	1,4	0,9	0,742	0,310	0,432
	4	-0,1	-0,2	-0,053	0,062	-0,115
	5	0	0,1	0	-0,062	0,062
	6	1,8	1,6	0,954	0,124	0,830
	7	0,2	0,2	0,106	0,000	0,106
	8	0,5	0,4	0,265	0,062	0,203
	9	0,5	0,4	0,265	0,062	0,203
	10	-0,2	-0,2	-0,106	0,000	-0,106
	11	0	0,1	0	-0,062	0,062
	12	0,3	0,3	0,159	0,000	0,159
	13	3	2,2	1,59	0,496	1,094
	14	1,8	1,6	0,954	0,124	0,830
	15	0,1	0,2	0,053	-0,062	0,115
	16	0	0	0	0,000	0,000
	17	0,3	0,3	0,159	0,000	0,159
	18	0	0,1	0	-0,062	0,062
	19	0,5	0,3	0,265	0,124	0,141
	20	2,6	1,9	1,378	0,434	0,944
	21	0,1	0	0,053	0,062	-0,009
	22	0,1	0	0,053	0,062	-0,009
	23	0,7	0,2	0,371	0,310	0,061
	24	0,4	0,3	0,212	0,062	0,150
	25	1	0,7	0,53	0,186	0,344
	26	0,7	0,7	0,371	0,000	0,371
	27	1,2	1	0,636	0,124	0,512
	28	1	1	0,53	0,000	0,530
	29	0,2	0	0,106	0,124	-0,018
	30	0	-0,2	0	0,124	-0,124
Average				**0,33**		

Haul 4

	1	2,1	1,7	1,113	0,248	0,865
	2	2,2	1,8	1,166	0,248	0,918
	3	1	0,8	0,53	0,124	0,406
	4	1,3	0,9	0,689	0,248	0,441
	5	1,4	0,9	0,742	0,310	0,432
	6	1,2	0,8	0,636	0,248	0,388
	7	4,6	3,5	2,438	0,682	1,756
	8	0,6	0,4	0,318	0,124	0,194
	9	5,1	3,9	2,703	0,744	1,959
	10	1,6	1,4	0,848	0,124	0,724
	11	2	1,5	1,06	0,310	0,750
	12	0,4	0,4	0,212	0,000	0,212
	13	2,2	1,7	1,166	0,310	0,856
	14	5,3	4,1	2,809	0,744	2,065
	15	1,2	1,2	0,636	0,000	0,636
	16	0,8	0,4	0,424	0,248	0,176
	17	2,3	2	1,219	0,186	1,033
	18	3,4	3,3	1,802	0,062	1,740
	19	2,4	1,8	1,272	0,372	0,900
	20	0	0	0	0,000	0,000
	21	3,2	2,6	1,696	0,372	1,324
	22	0	-0,2	0	0,124	-0,124
	23	1,5	1,3	0,795	0,124	0,671
	24	3,3	2,9	1,749	0,248	1,501
	25	2,6	2,1	1,378	0,310	1,068
	26	4,6	3,3	2,438	0,806	1,632
	27	1,6	1,5	0,848	0,062	0,786
	28	0,8	0,8	0,424	0,000	0,424
	29	2	1,2	1,06	0,496	0,564
	30	1,1	1	0,583	0,062	0,521
Average				**1,11**		

Haul 4

	1	2,1	1,6	1,113	0,310	0,803
	2	4,1	3,3	2,173	0,496	1,677
	3	2,9	2,4	1,537	0,310	1,227
	4	-0,2	-0,2	-0,106	0,000	-0,106
	5	7,1	6	3,763	0,682	3,081
	6	4,3	3,5	2,279	0,496	1,783
	7	1,5	1,2	0,795	0,186	0,609
	8	4,1	3,4	2,173	0,434	1,739
	9	5,4	4,3	2,862	0,682	2,180
	10	5,3	4	2,809	0,806	2,003
	11	1,7	1,3	0,901	0,248	0,653
	12	3,3	2,7	1,749	0,372	1,377
	13	0,6	0,5	0,318	0,062	0,256
	14	1,1	1	0,583	0,062	0,521
	15	3,2	3	1,696	0,124	1,572
	16	3,9	3,3	2,067	0,372	1,695
	17	1,8	1,3	0,954	0,310	0,644
	18	0	0	0	0,000	0,000
	19	3,5	2,8	1,855	0,434	1,421
	20	1,1	0,7	0,583	0,248	0,335
	21	2,6	2	1,378	0,372	1,006
	22	0,7	0,9	0,371	-0,124	0,495
	23	4	3,4	2,12	0,372	1,748
	24	2	1,7	1,06	0,186	0,874
	25	4,4	3,5	2,332	0,558	1,774
	26	1,1	0,8	0,583	0,186	0,397
	27	2,8	2,2	1,484	0,372	1,112
	28	1,3	0,9	0,689	0,248	0,441
	29	1,1	0,7	0,583	0,248	0,335
	30	3,8	3,3	2,014	0,310	1,704
Average				**1,40**		

Haul 4

	1	1,5	0,8	0,795	0,434	0,361
	2	3,2	2,3	1,696	0,558	1,138
	3	3,3	2,6	1,749	0,434	1,315
	4	6,1	4,4	3,233	1,054	2,179
	5	2,4	1,8	1,272	0,372	0,900
	6	1,6	1,1	0,848	0,310	0,538
	7	3	2,4	1,59	0,372	1,218
	8	2,9	1,9	1,537	0,620	0,917
	9	1,9	1,4	1,007	0,310	0,697
	10	0,6	0,5	0,318	0,062	0,256
	11	2,6	2,1	1,378	0,310	1,068
	12	3,1	2,2	1,643	0,558	1,085
	13	1,1	0,8	0,583	0,186	0,397
	14	1	0,6	0,53	0,248	0,282
	15	1,4	1,2	0,742	0,124	0,618
	16	2,4	1,8	1,272	0,372	0,900
	17	6,8	5,5	3,604	0,806	2,798
	18	4	3,4	2,12	0,372	1,748
	19	2	1,6	1,06	0,248	0,812
	20	1,8	1,4	0,954	0,248	0,706
	21	2	1,5	1,06	0,310	0,750
	22	3,2	2,5	1,696	0,434	1,262
	23	2,2	1,6	1,166	0,372	0,794
	24	1,7	1,3	0,901	0,248	0,653
	25	1,2	0,9	0,636	0,186	0,450
	26	2,6	1,9	1,378	0,434	0,944
	27	3,3	2,7	1,749	0,372	1,377
	28	3	2,3	1,59	0,434	1,156
	29	2,6	2,2	1,378	0,248	1,130
	30	1,5	1,4	0,795	0,062	0,733
Average				**1,33**		

Haul 5

	1	1,6	1,1	0,848	0,310	0,538
	2	0,4	0,2	0,212	0,124	0,088
	3	2,3	1,7	1,219	0,372	0,847
	4	3,9	3,1	2,067	0,496	1,571
	5	0,1	0	0,053	0,062	-0,009
	6	1,3	1,1	0,689	0,124	0,565
	7	3,1	2,7	1,643	0,248	1,395
	8	1,4	1	0,742	0,248	0,494
	9	0,9	0,6	0,477	0,186	0,291
	10	0,9	0,7	0,477	0,124	0,353
	11	-0,1	0	-0,053	-0,062	0,009
	12	2,4	2	1,272	0,248	1,024
	13	3,2	2,8	1,696	0,248	1,448
	14	0,9	1	0,477	-0,062	0,539
	15	1,6	1,6	0,848	0,000	0,848
	16	3,3	2,4	1,749	0,558	1,191
	17	1,6	1,7	0,848	-0,062	0,910
	18	3,3	3	1,749	0,186	1,563
	19	0,4	0,3	0,212	0,062	0,150
	20	1,5	1,1	0,795	0,248	0,547
	21	0	0	0	0,000	0,000
	22	1,2	1	0,636	0,124	0,512
	23	6,7	5,5	3,551	0,744	2,807
	24	2,4	2,1	1,272	0,186	1,086
	25	0,4	0,4	0,212	0,000	0,212
	26	0,9	0,8	0,477	0,062	0,415
	27	0,6	0,5	0,318	0,062	0,256
	28	0	0	0	0,000	0,000
	29	1,1	1	0,583	0,062	0,521
	30	3,6	3,3	1,908	0,186	1,722
Average				**0,91**		

Haul 5	1	1,6	1,1	0,848	0,310	0,538
	2	3,2	2,6	1,696	0,372	1,324
	3	0,9	0,6	0,477	0,186	0,291
	4	0,9	0,6	0,477	0,186	0,291
	5	2,9	2,1	1,537	0,496	1,041
	6	0,4	0,2	0,212	0,124	0,088
	7	0,5	0,3	0,265	0,124	0,141
	8	0,2	0	0,106	0,124	-0,018
	9	-0,4	-0,4	-0,212	0,000	-0,212
	10	0,9	0,6	0,477	0,186	0,291
	11	5,5	4,5	2,915	0,620	2,295
	12	0,3	0	0,159	0,186	-0,027
	13	0,6	0,2	0,318	0,248	0,070
	14	0,1	0	0,053	0,062	-0,009
	15	-0,2	-0,4	-0,106	0,124	-0,230
	16	0,1	-0,2	0,053	0,186	-0,133
	17	3,3	2,9	1,749	0,248	1,501
	18	4,6	3,6	2,438	0,620	1,818
	19	0,4	0,2	0,212	0,124	0,088
	20	0,2	0	0,106	0,124	-0,018
	21	0,4	0,3	0,212	0,062	0,150
	22	1	0,8	0,53	0,124	0,406
	23	2,9	2,3	1,537	0,372	1,165
	24	5	4,2	2,65	0,496	2,154
	25	0,5	0,5	0,265	0,000	0,265
	26	3,3	2,9	1,749	0,248	1,501
	27	-0,1	0	-0,053	-0,062	0,009
	28	1,5	0,9	0,795	0,372	0,423
	29	2,5	1,9	1,325	0,372	0,953
	30	1,6	1,2	0,848	0,248	0,600
Average				**0,76**		

Haul 5	1	3,6	3	1,908	0,372	1,536
	2	2,3	1,5	1,219	0,496	0,723
	3	3	2,8	1,59	0,124	1,466
	4	0,5	0,4	0,265	0,062	0,203
	5	1,8	1,2	0,954	0,372	0,582
	6	0,7	0,5	0,371	0,124	0,247
	7	0,9	0,5	0,477	0,248	0,229
	8	1,3	1	0,689	0,186	0,503
	9	0	-0,2	0	0,124	-0,124
	10	1,4	0,8	0,742	0,372	0,370
	11	1,4	0,7	0,742	0,434	0,308
	12	1,8	1,3	0,954	0,310	0,644
	13	1,9	1,5	1,007	0,248	0,759
	14	1,4	1,1	0,742	0,186	0,556
	15	0	0	0	0,000	0,000
	16	5,7	4,3	3,021	0,868	2,153
	17	1,7	1,3	0,901	0,248	0,653
	18	0,4	0,2	0,212	0,124	0,088
	19	3,4	2,7	1,802	0,434	1,368
	20	-0,5	-0,3	-0,265	-0,124	-0,141
	21	2,3	2	1,219	0,186	1,033
	22	0,8	0,5	0,424	0,186	0,238
	23	3,3	2,5	1,749	0,496	1,253
	24	1,8	1,4	0,954	0,248	0,706
	25	2,9	2,5	1,537	0,248	1,289
	26	0,9	0,7	0,477	0,124	0,353
	27	3,1	2,1	1,643	0,620	1,023
	28	0,9	0,7	0,477	0,124	0,353
	29	1,5	1,1	0,795	0,248	0,547
	30	0,7	0,4	0,371	0,186	0,185
Gj snitt				**0,82**		

APPENDIX 4 Copepod mandibles found in stomachs of krill

Haul 1	60-0 m	
Krill	Mandibles	Species
1	0	
2	0	
3	0	
4	1	Acartia el T. longicornis
5	0	
6	0	
7	0	
8	1	Not identified
9	0	
10	0	
11	0	
12	0	
13	0	
14	0	
15	0	
16	0	
17	2	Acartia, Oithona
18	1	Temora
19	2	Calanus spp, Temora spp
20	0	
21	0	
22	0	
23	0	
24	0	
25	0	
26	0	
27	0	
28	0	
29	0	
30	0	
	7	

	90-60 m	
1	2	Calanus spp
2	0	
3	2	Metridia, calanus
4	0	
5	0	
6	0	
7	2	Not identified
8	0	
9	0	
10	1	Not identified
11	0	
12	1	Not identified
13	0	
14	0	
15	0	
16	1	Not identified
17	0	
18	0	
19	0	
20	0	
21	0	
22	0	
23	0	
24	2	Not identified
25	0	
26	0	
27	0	
28	0	
29	0	
30	0	
	11	

	135-90	
1	0	
2	0	
3	1	Not identified
4	2	Calanus spp, Calanus spp
5	0	0
6	0	0
7	2	Calanus, Metridia
8	0	
9	0	
10	0	
11	0	
12	3	Calanus spp, Calanus spp, Acartia
13	0	
14	0	
15	0	
16	0	
17	0	
18	0	
19	0	
20	0	
21	0	
22	0	
23	1	Not identified
24	0	
25	0	
26	1	Calanus spp
27	0	
	10	

Haul 2	**137-123 m**	
Krill		
1	0	
2	3	Temora, not identified x 2
3	2	Calanus spp, uident
4	1	Temora
5	1	Calanus spp
6	0	
7	0	
8	0	
9	0	
10	1	Not identified
11	0	
12	0	
13	4	Calanus spp, not identified, Acartia(?), microcalanus(?)
14	0	
15	3	Not identified, Oithona x 1
16	0	
17	1	Not identified
18	0	
19	0	
20	0	
21	0	
22	0	
23	0	
24	0	
25	1	Oithona
26	1	Not identified
27	0	
28	0	
29	0	
30	0	

Haul 5	105-90 m	
1	1	Calanus spp
2	0	
3	1	Not identified
4	0	
5	1	Calanus spp
6	0	
7	0	
8	0	
9	0	
10	0	
11	5	calanus spp, calanus spp, not identified, calanus spp, calanus spp
12	0	Calanus spp
13	0	
14	2	Calanus spp, calanus spp
15	0	
16	1	Calanus spp
17	0	
18	0	
19	1	Calanus spp
20	0	
21	0	
22	0	
23	0	
24	1	Acartia
25	3	not identified, Calanus stage 2, Acartia
26	0	
27	1	Not identified
28	0	
29	1	Pseudocalanus
30	0	
	18	

SPRAT

APPENDIX 5

Bunnefjorden

24.11.2005		**Haul 1**	**Net 1**	**Depth (m) 105-90**		**Time 12.55-13.11**	
Sprat	**length (cm)**	**tot.length (cm)**	**weight (g)**	**rate of digestion**		**stomach fullness**	**gut content**
1	11,0	12,5	14,12		0	2	empty
2	9,0	11,0	7,86		5	2	empty
3	13,5	15,5	25,05		0	2	empty
4	12,5	14,0	19,70		0	2	empty
5	12,5	14,0	17,46		0	2	empty
6	11,5	13,5	17,11		0	2	empty
7	11,5	13,5	18,57		0	2	empty
8	11,0	12,5	14,62		0	2	empty
9	11,0	12,5	14,33		0	2	empty
10	12,5	14,5	19,04		0	2	empty
11	12,0	14,0	19,65		0	2	empty
12	8,0	9,0	4,35		0	2	empty
13	12,0	14,0	17,12		0	2	empty
14	11,0	12,5	12,86		0	2	empty
15	10,0	11,5	10,74		0	2	empty
16	8,5	10,0	10,72		0	2	empty
17	10,0	12,0	6,08		0	2	empty
18	10,5	12,0	12,97		0	2	empty
19	10,5	12,5	14,03		0	2	empty
20	11,0	12,5	13,50		0	2	empty
21	8,0	9,0	5,88		0	2	empty
22	8,0	9,0	5,02		0	2	empty
23	12,5	14,5	21,91		0	2	empty
24	9,5	11,5	9,39		0	2	empty
25	10,5	12,5	11,03		0	2	empty

	26	9,5	11,0	8,35	0	2	empty
	27	12,5	14,0	18,95	0	2	empty
	28	13,0	15,0	22,73	0	2	empty
	29	11,0	13,0	16,10	0	2	empty
	30	10,0	11,5	10,20	0	2	empty
Average		10,8	12,5	13,98	Walls of gut consist of white "mush"		

24.11.2005			**Trekk 1**	**Nett 2**	**Dyp (m) 90-626**	**Tid 13.17-13.29**	
Sprat		**length (cm)**	**tot.length (cm)**	**weight (g)**	**rate of digetion**	**stomach fullness**	**gut content**
	1	12	14	18,02	0	2	empty

25.11.2005			**Trekk 1**	**Nett 1**	**Dyp (m) 120-86**	**Tid 09.55-10.17**	
Sprat		**length (cm)**	**tot.length (cm)**	**weight (g)**	**rate of digetion**	**stomach fullness**	**gut content**
	1	13,5	15,5	24,38	0	2	empty
	2	12,5	14,5	19,57	0	2	empty
	3	12,5	14,5	21,42	0	2	empty
	4	13,0	15,0	19,97	0	2	empty
	5	11,0	13,0	12,32	0	2	empty
	6	14,0	17,0	30,40	0	2	empty
	7	12,5	15,0	20,45	5	2	empty
	8	11,0	15,0	15,12	0	2	empty
	9	10,5	12,0	11,44	0	2	empty
	10	9,5	11,0	7,83	0	2	empty
	11	12,0	14,0	19,47	0	2	empty
	12	12,0	12,0	17,97	0	2	empty
	13	11,5	13,5	15,36	0	2	empty
	14	12,5	14,5	21,12	0	2	empty
	15	10,0	11,5	9,47	0	2	empty

16	12,0	15,0	19,68	0	2	empty
17	12,5	14,0	18,14	0	2	empty
18	10,0	11,5	11,13	0	2	empty
19	11,0	12,5	13,53	0	2	empty
20	10,5	12,0	10,94	5	2	empty
21	12,0	14,0	18,92	0	2	empty
22	10,5	12,5	13,60	0	2	empty
23	10,0	11,5	10,96	0	2	empty
24	13,0	15,0	22,70	0	2	empty
25	12,0	14,0	18,18	5	2	empty
26	11,0	13,0	14,66	5	2	empty
27	11,0	13,0	15,05	0	2	empty
28	11,5	13,5	19,12	0	2	empty
29	10,5	12,5	13,10	0	2	empty
30	10,5	12,5	14,23	0	2	empty
Average	11,5	13,5	16,67	Walls of gut consist of white "mush"		

13.12.2005	_	**Haul 1**	**Net 1**	**Depth (m) 135-95 m**	_	_	**Time 11.43 - 12.04**	_
Sprat	**length (cm)**	**tot.length (cm)**	**weight (g)**	**digestion rate**			**stomach fullness**	**gut content**
1	11	12,5	13,82	0	0		2	empty
2	11	12	12,33	0	0		2	empty
3	7,5	9	3,92	0	0		2	empty
4	9,5	11	9,56	0	0		2	empty
5	9,5	11	7,85	4	5		2	copepods (4) krill?, remains (5)
6	11,5	13	12,82	0	0		2	empty
7	8	9,5	4,91	0	0		2	empty
8	7,5	8,5	3,75	0	0		2	empty
9	12	13,5	17,36	0	0		2	empty
10	8	9	4,36	0	0		2	empty
11	12	14	18,23	4	0		3	1 copepod (4)

12	10	11,5	10,17	0	0		2	empty
13	10,5	12,5	11,58	0	0		2	empty
14	8	9,5	4,68	5	0		3	remains (5)
15	8,5	10	5,4	0	0		2	empty
16	8,5	9,5	5,76	0	0		2	empty
17	9	11	8,3	0	0		2	empty
18	8,5	10	5,48	0	0		2	empty
19	10	12,5	11,25	0	0		2	empty
20	11	13	13,06	0	0		2	empty
21	9	11	9,34	5	0		2	remains (5)
22	13	15	21,29	0	0		2	empty
23	8,5	9,5	4,99	0	0		2	empty
24	7	8	3	5	0		2	remains (5)
25	7,5	8,5	3,85	0	0		2	empty
26	10	11,5	9,86	0	0		2	empty
27	7	8	3,71	0	0		2	empty
28	10	11,5	9,32	0	0		2	empty
29	10,5	12,5	13,36	0	0		2	empty
30	10	11,5	10,49	0	0		2	empty
st.dev		1,9	4,8					
Average		11,0	9,1					

		Haul 1	**Net 2**	**Depth (m) 90 - 60 m**			**Time 12.05 - 12.13**	
Sprat	**length (cm)**	**tot.length (cm)**	**weight (g)**	**digestion rate**			**stomach fullness**	**gut content**
1	10	11,5	8,95	4	5		3	remains
2	10	11,5	8,73	0	0		2	empty
3	6,5	7,5	2,22	0	0		2	empty
St. dev		2,3	3,8					
Average		10,2	6,6					

-	-	Haul 2	Net 1	Depth (m) 137 - 123 m			Time 14.13 - 14.24	-
Sprat		length (cm)	tot.length (cm)	weight (g)	digestion rate		stomach fullness	gut content
1	12,5	14,5	19,07		0	0	2	empty
2	11	12,5	11,86		0	0	2	empty
3	11	13	12,42		0	0	2	empty
4	8,5	10	6,02		0	0	2	empty
5	6,5	8	2,64		0	0	2	empty
6	11	12,5	13,49		0	0	2	empty
7	11	12,5	12,54		0	0	2	empty
8	10	12	9,11		0	0	2	empty
9	8	9	4,15		0	0	2	empty
10	8,5	9,5	5,08		0	0	2	empty
11	11	12,5	13,25		0	0	2	empty
12	9,5	11	7,9		0	0	2	empty
13	9,5	11	7,22		0	0	2	empty
14	10	11,5	9,56		0	0	2	empty
15	6	7,5	2,51		0	0	2	empty
16	9	10,5	6,98		0	0	2	empty
17	9,5	11,5	10,61		0	0	2	empty
18	9,5	11	8,39		0	0	2	empty
19	8	9	3,87		0	0	2	empty
20	10	12	10,86		5	0	2	remains
21	10	12	10,03		0	0	2	empty
22	10	12	11,32		0	0	2	empty
23	10	12	10,13		0	0	2	empty
24	10	12	12,81		0	0	2	empty
25	10,5	12,5	12,35		0	0	2	empty
26	11,5	13,5	17,06		5	0	2	remains
27	9,5	11	9,37		0	0	2	empty
28	10	11,5	8,75		5	0	2	remains
29	8,5	10	6,11		0	0	2	empty

30	7	8	2,55	0	0	2	empty
St. dev		1,7	4,1				
Average		11,2	9,3				

		Haul 2	Net 2	Depth (m) 120-104 m		Time 14.24 - 14.34	
Sprat	**length (cm)**	**tot.length (cm)**	**weight (g)**	**digestion rate**		**stomach fullness**	**gut content**
1	11	13	12,87	2	0	2	1 calanus
2	10,5	12	10,98	0	5	2	remains
3	10,5	12	11,47	0	0	2	empty
4	10	11,5	10,42	2	0	2	1 calanus
5	10,5	12,5	13,66	2	0	2	1 calanus
6	10,5	12	12,65	0	0	2	empty
7	11,5	13	15,45	0	0	2	empty
8	10,5	12	9,83	2	0	2	1 calanus
9	10,5	12,5	11,68	0	0	2	empty
10	10	11,5	9,46	5	0	3	grøt
11	10	12,5	11,25	5	0	2	remains
12	9,5	11	8,21	5	0	3	remains
13	8	9,5	5,51	5	0	2	remains
14	7	8,5	3,73	0	0	2	empty
15	7	8	3,48	0	0	2	empty
Average		11,4	10,0				

		Haul 2	Net 3	Depth (m) 97-86 m		Time 14.35 - 14.47	
Sprat	**length (cm)**	**tot.length (cm)**	**weight (g)**	**digestion rate**		**stomach fullness**	**gut content**
1	11	13	13,76	0	0	2	empty
2	10	12	12,44	0	0	2	empty
3	10	11,5	10,06	0	0	2	empty

	4	9	10	7,46	0	0	2	empty
	5	8,5	9,5	5,68	0	0	2	empty
	6	8,5	10	6,14	0	0	2	empty
Average			11	9,3				

NIGHT

		Haul 3	Net 1	Depth (m) 120-98 m			Time 18.06 - 18.24	
Sprat		length (cm)	tot.length (cm)	weight (g)	digestion rate		stomach fullness	gut content
	1	11	13	14,29	0	0	2	empty
	2	11	12,5	13,17	0	0	2	empty
	3	10,5	12	12,15	0	0	2	empty
	4	11	13	12,74	0	0	2	empty
	5	11	12,5	11,49	0	0	2	empty
	6	10	12	11,14	0	0	2	empty
	7	9,5	11	8,19	0	0	2	empty
	8	9	10,5	7,4	0	0	2	empty
	9	8	9,5	5,1	0	0	2	empty
	10	7,5	9	4,21	5	0	2	remains
	11	12	14	18,24	5	0	2	litt grøt
	12	8	9,5	5	0	0	2	empty
	13	10	12	11,19	0	0	2	empty
	14	7,5	8,5	3,8	0	0	2	empty
	15	8	9,5	5,23	0	0	2	empty
	16	8	9	4,9	0	0	2	empty
	17	10	11,5	10,06	0	0	2	empty
	18	10	12	10,03	0	0	2	empty
	19	11	12,5	12,17	0	0	2	empty
	20	10,5	12	10,69	0	0	2	empty
	21	10	11,5	10,29	0	0	2	empty
	22	10	11,5	10,88	0	0	2	empty

	23	9,5	10,5	6,93	5	0	2	remains
	24	11	12,5	12,63	5	0	2	remains
	25	12,5	14,5	18,88	0	0	2	empty
	26	9,5	11	8,27	5	2	2	1 calanus (2), remains (5)
	27	10	11,5	10,24	0	0	2	empty
	28	7,5	9	5,1	0	0	2	empty
	29	8,5	9,5	6,08	0	0	2	empty
	30	8,5	10	6,22	0	0	2	empty
St,dev			1,6	3,9				
Average			11,2	9,6				

		Haul 3	Net 2	Depth (m) 91 - 61 m			Time 18.24 - 18.38	
Sprat	**length (cm)**	**tot.length (cm)**	**weight (g)**	**digestion rate**			**stomach fullness**	**gut content**
1	10,5	12	11,65		0	0	2	empty
2	10,5	12	12,09		0	0	2	empty
3	10,5	12	12,81		0	0	2	empty
4	10,5	12	11		0	0	2	empty
5	9	10,5	7,08		0	0	2	empty
6	8	9,5	5,02		0	0	2	empty
7	8	9	4,64		0	0	2	empty
8	8	9	4,16		0	0	2	empty
9	7	8,5	3,77		0	0	2	empty
10	7	8	3,46		0	0	2	empty
11	10,5	12,5	12,47		0	0	2	empty
12	9,5	11	8,56		0	0	2	empty
13	8,5	10	6,31		0	0	2	empty
14	8,5	10	5,97		0	0	2	empty
15	7,5	8,5	3,94		0	0	2	empty
16	10,5	12	11,01		0	0	2	empty
17	9,5	11	8,72		0	0	2	empty
18	9,5	11,5	8,84		0	0	2	empty
19	9,5	11	8,5		0	0	2	empty

20	8,5	10	5,37	2	3	4	5	4	1 acartia (2),remains, many copepods- mostly calanus (50
21	10,5	12,5	12,94	0	0			2	empty
22	9,5	11,5	8,95	0	0			2	empty
23	7,5	9	4,47	0	0			2	empty
24	7,5	9	4,22	0	0			2	empty
25	9	10,5	7,33	0	0			2	empty
26	7,5	8,5	3,76	0	0			2	empty
27	7	8	3,2	0	0			2	empty
28	7	8	2,77	0	0			2	empty
29	6	6,5	1,71	0	0			2	empty
30	6	7	2,17	0	0			2	empty
St dev		1,7	3,5						
Average		10,0	6,9						

		Haul 3	**Net 3**	**Depth (m) 57-3 m**				**Time 18.40 - 18.55**	
Sprat	**length (cm)**	**tot.length (cm)**	**weight (g)**	**digestion rate**				**stomach fullness**	**gut content**
1	12,5	14	18,22	0	0			2	empty
2	10,5	12	11,39	0	0			2	empty
3	7,5	8,5	3,8	4	5			3	remains
4	7	8	3,1	3	4	5		3	6 acartia (3), remains (5+4)
5	6,5	7,5	2,29	3	4	5		2	2 acartia (3), remains with copepode (4+5)
St.dev		2,9	6,9						
Average		10	7,76						

		Haul 4	**Net 1**	**Depth (m) 60-40 m**				**Time 19.37 - 19.52**	
Sprat	**length (cm)**	**tot.length (cm)**	**weight (g)**	**digestion rate**				**stomach fullness**	**gut content**
1	10,5	12,5	11,58	4	5			2	1 euchaeta (4), remains

2	8	9,5	5,8	4	5			3	remains, små copepode rester acartia og noen calanus re
3	9	10,5	8,09	0	0			2	empty
4	7,5	9	4,35	5	0			3	copepode remains
5	7,5	9	4,21	5	0			3	copepod remains
6	7,5	9	3,96	4	5			3	3-4 calanus, the rest is copepod remains
7	7	8,5	3,4	4	5			3	ca 10 acartia, copepod remains
8	6,5	7,5	2,44	4	5			3	ca 20 acartia, 1 calanus, remains
9	6,5	7,5	2,6	3	4	5		3	ca 40-50 acartia, copepod remains
10	6,5	7,5	2,66	5	0			3	copepod remains
11	8	9,5	6,47	4	5			3	copepod remains with acartia (ca 10)
12	7,5	9	4,02	4	5			3	copepod remains with acartia (ca 5-10)
13	7	8	3,26	3	4	5		3	copepod remains, less calanus many acartia >100
14	7,5	8,5	3,63	4	5			3	copepod remains with acartia (ca 20)
15	7,5	9	4,22	4	5			3	copepod remains with acartia (ca 20)
16	7	8	2,98	3	4	5		4	a little calanus remains få calanus (4), many acartia (ca 10
17	7	8	3,53	4	5			4	grøt få calanus (4), mye acartia (ca 100)
18	6,5	7,5	2,64	2	3	4	5	4	1 temora (2), few calanus, remains with acartia >100
19	6,5	7,5	2,53	4	5			3	copepod remains, few calanus, acartia (ca 20-30)
20	5,5	6,5	1,78	3	4	5		3	copepod remains with acartia (ca 100)
21	8	9	5,11	3	4	5		3	copepod remains (4-5 calanus) (4) acartia (20-30 stk)
22	7,5	9	9,52	2	3	4	5	4	1 temora(2), få calanus, many acatia (50-60)
23	7	8,5	3,5	2	3	4	5	4	2 temora (2) remains with a few calanus, many acartia (ca
24	7	8,5	3,48	3	4	5		3	a few calanus, many acartia (50-60)
25	7	8,5	3,53	3	4	5		4	1 calanus(3), many acartia (ca 100)
26	7,5	9	4,46	2	3	4	5	3	1 centropages(2), 1 temora (3), calanus (ca 5-6), few acar
27	6,5	8	3,13	2	3	4	5	4	1 temora (2), 5 calanus (4), acartia (3+4) (70-80 stk)
28	7,5	9	4,55	3	4	5		3	a few calanus remains, ca 20 acartia (3+4)
29	7	8	3,44	3	4	5		3	a few calanus remains, 20-30 acartia
30	6	7	2,02	1	2	4	5	4	1 centropages(1), 1 temora (2), calanus (4) 10,acartia (2-4
Average		8,6	4,2						

-	-	**Haul 4**	**Net 3**	**Depth (m) 15-1 m**	**Time 20.02 - 20.20**	-

Sprat	length (cm)	tot.length (cm)	weight (g)	digestion rate				stomach fullness	gut content
1	6,5	7,5	2,42		3	4	5	4	acartia ca 30 stk (3+4), remains of smaller copepods(4), re
Average		7,5	2,42						

-	-	Haul 5	Net 1	Depth (m) 125-129 (135)				Time 21.00 - 21.11	-
Sprat	length (cm)	tot.length (cm)	weight (g)	digestion rate				stomach fullness	gut content
1	12	14	18,7		0	0		2	empty
2	10	12,5	9,57		0	0		1	empty
3	10	11,5	10,28		0	0		2	empty
4	8,5	10	6,13		0	0		1	empty
5	9,5	11	8,36		0	0		2	empty
6	8,5	10	5,87		0	0		2	empty
7	12,5	14	18,79		5	3	4	3	not identified (3-4),
8	11	12,5	13,05		0	0		2	empty
9	10,5	12,5	11,71		0	0		2	empty
10	10	12	11,22		0	0		2	empty
11	10,5	12	11,03		0	0		2	empty
12	10	11,5	9,26		0	0		2	empty
13	8	9,5	4,48		0	0		2	empty
14	8,5	7	3,03		0	0		2	empty
15	10	12	10,36		0	0		2	empty
16	11	12,5	10,83		0	0		2	Not identified (3-4)
17	9,5	11	8,01		0	0		2	empty
18	10	12	10,98		0	0		2	empty
19	10	12	10,24		0	4		2	not identified (4)
20	10,5	12	10,6		0	0		2	empty
21	10	11,5	10		0	0		2	empty
22	9,5	11	8,06		0	0		2	empty

23	9,5	11,5	9,57		0	0	2	empty
24	10	11,5	10,06		0	0	2	empty
25	8	9	4,61		0	0	2	empty
26	12	14	12,3		0	0	2	empty
27	6,5	8	2,59		0	0	2	empty
28	9	11	8,12		0	0	2	empty
29	10	11,5	9,13		0	0	2	empty
30	8	9,5	5,11		0	0	2	empty
St.dev		1,6	3,7					
	Average	11,3	9,4					

		Haul 5	Net 2	Depth (m) 122 - 110			Time 21.15 - 21.25	
Sprat	**length (cm)**	**tot.length (cm)**	**weight (g)**	**digestion rate**			**stomach fullness**	**gut content**
1	9	10,5	8,23		0	0	2	empty
2	10,5	12,5	13,82		0	0	2	empty
3	11	13	15,01		0	0	2	empty
4	10,5	13,5	13,81		0	0	2	empty
5	10,5	12,5	15,11		0	0	2	empty
6	10	12	10,31		0	0	2	empty
7	10	12	11,67		0	0	2	empty
8	10,5	12,5	12,46		0	0	2	empty
9	10,5	12	13,1		0	0	2	empty
10	9,5	11,5	9,59		0	0	2	empty
11	8	9,5	5,72		0	0	2	empty
12	7,5	8,5	3,96		0	0	1	empty
13	10	12,5	11,39		0	0	2	empty
14	11	13	12,63		0	0	2	empty
15	11	12,5	12,29		0	0	2	empty
16	10,5	12	11,8		0	0	2	empty
17	10	11,5	10,34		0	0	2	empty
18	10	12	9,7		0	0	1	empty

	19	10,5	12,5	12,21	0	0	2	empty
	20	10,5	12,5	12,87	0	0	2	not identified
	21	10	12	10,75	0	0	2	empty
	22	10	11,5	9,18	0	0	2	empty
	23	9	10,5	7,93	0	0	2	empty
	24	8	9	4,12	0	0	2	empty
	25	9,5	11,5	9,28	0	0	2	empty
	26	10,5	12,5	12,2	0	0	2	empty
	27	11	13	15,88	0	0	2	empty
	28	11	13	14,54	0	0	2	empty
	29	8	9	4,67	0	0	2	empty
	30	8	9,5	4,69	0	0	2	empty
Average			11,7	10,6				

-	-	**Haul 5**	**Net 3**	**Depth (m) 105 - 90**			**Time 21.26 - 21.36**	-
Sprat	**length (cm)**	**tot.length (cm)**	**weight (g)**	**digestion rate**			**stomach fullness**	**gut content**
1	7,5	9	3,78		0	0	2	empty
2	7	8,5	3,54		0	0	2	empty
3	10	11,5	9,19		0	0	2	empty
4	11	12,5	13,31		0	0	2	empty
5	11	13	13,59		0	0	2	empty
6	10	12,5	12,11		0	0	2	empty
7	10,5	12	12,79		0	0	2	empty
8	11,5	13,5	16,1		0	0	2	empty
9	7	8	3,1		0	0	1	empty
10	8,5	10	6,1		0	0	1	empty
11	10	11,5	10,17		0	0	2	empty
12	10	11,5	9,91		0	0	2	empty
13	10	11,5	11,25		0	0	2	empty
14	10	12	10,06		0	0	2	empty
15	12	14	211,32		0	0	2	empty

16	12,5	14,5	22,9		0	0	2	empty
17	9,5	11,5	9,7		0	0	2	empty
18	9,5	11,5	9,9		0	0	2	empty
19	10,5	12	11,43		0	0	2	empty
20	9,5	11	6,25		0	0	2	empty
21	7	8,5	3,54		0	0	2	empty
22	7,5	9,5	4,95		4	5	4	remains (5), parts of acartia 20-30 stk (4)
23	7	8	3,22		0	0	2	empty
24	7,5	8,5	3,55		0	0	2	empty
25	7,5	8,5	4,06		0	0	2	empty
26	8	9,5	5,95		0	0	2	empty
27	9	10,5	8,16		0	0	2	empty
28	11,5	13	15,02		0	0	2	empty
29	13	15	23,23		0	0	2	empty
30	13	15	24,32		0	0	2	empty
Average		11,25	16,75					

04.01.06	_	**Haul 1**	**Net 1**	**Depth (m) 134 - 96**			**Time 11.57 - 12.16**	_
Sprat	**length (cm)**	**tot.length (cm)**	**weight (g)**	**digestion rate**			**stomach fullness**	**Stomach content**
1	10	11,5	9,84		0	0	2	empty
2	9,5	11,5	8,93		0	0	2	empty
3	10	11,5	9,52		0	0	2	empty
4	8,5	9,5	5,17		0	0	2	empty
5	8	9,5	4,77		0	0	2	empty
6	7	8	3,46		0	0	2	empty
7	6,5	7,5	2,33		0	0	2	empty
8	5,5	6,5	1,53		0	0	2	empty
9	10	12	10,51		0	0	2	empty
10	10	11,5	11,04		0	0	2	empty

11	9,5	11	8,45	0		0	2	empty
12	8	9	4,58	0		0	2	empty
13	7,5	9	4,16	0		0	2	empty
14	7	8,5	3,1	0		0	2	empty
15	7	8,5	3,14	0		0	2	empty
16	7	8	2,6	0		0	2	empty
17	6	7,5	2,55	0		0	2	empty
18	10,5	12	10,98	0		0	2	empty
19	11,5	13,5	16,04	0		0	2	empty
20	12	14	16,96	0		0	2	empty
21	12	14	11,1	0		0	2	empty
22	9,5	11	7,67	0		0	2	empty
23	9	10,5	7,12	0		0	2	empty
24	7,5	8,5	3,62	0		0	2	empty
25	7,5	9	3,82	0		0	2	empty
26	7	8,5	3,44	0		0	2	empty
27	8	9,5	4,73	0		0	2	empty
28	10,5	12	11,51	0		0	2	empty
29	8,5	10	5,28	0		0	2	empty
30	7,5	9	3,67	0		0	2	empty
		2,0						
Average		10,1	6,7					

04.01.06	-	Haul 1	Net 2	Depth (m) 91 - 61			Time 12.19 - 12.36	-
Sprat	**length (cm)**	**tot.length (cm)**	**weight (g)**	**digestion rate**			**stomach fullness**	**Stomach content**
1	10	11,5	10,37	0			2	empty
2	10,5	12	11,04	3	5	4	4	10 calanus(3), remains(5)
3	7,5	9	4,13	2	3	2,5	4	17 calanus(2+3), 1 euchaeta(2)
4	8	9	4,89	0		0	2	empty
5	8	9,5	4,7	4	5	4,5	4	2 calanus? (4), remains(5)
6	7,5	9	4,09	0		0	2	empty
7	8	9	4,13	0		0	2	empty

8	8	9	3,87	0		0	2	empty
9	7,5	8,5	3,35	4	5	4,5	3	2 calanus (4), remains (5)
10	7,5	8,5	3,32	5		2,5	2	grøt(5)
11	10	12	12,51	0		0	2	empty
12	9,5	11	6,54	2	3	2,5	3	6 calanus(2+3)
13	8	9	4,22	2	4	3	3	8 calanus (2), gremains (4)
14	7,5	8,5	3,64	5		2,5	2	remains(5)
15	7,5	9	4,3	0		0	2	empty
16	8	9	4,15	4		2	2	1 calanus?(4)
17	8	9	4,17	4		2	2	copepod remains
18	7,5	9	3,84	3	5	4	3	6 calanus (3), remains(5)
19	7	8	3,07	0		0	2	empty
20	7	8	3	5		2,5	2	remains(5)
21	10,5	12	12,15	0		0	2	empty
22	10	11,5	10,02	4		2	3	copepod remains (smaller than calanus ca 10 (4)
23	10	11,5	7,93	3		1,5	2	1 calanus (3)
24	8,5	10	5,92	0		0	2	empty
25	8	9	4,52	0		0	2	empty
26	8,5	10	5,56	0		0	2	empty
27	7,5	9	3,78	0		0	2	empty
28	7,5	8,5	3,53	0		0	2	empty
29	7	8	3,31	0		0	2	empty
30	6,5	7,5	2,48	3	4	3,5	3	8 calanus? (3+4)
		1,3						
Average		9,5	5,4					

04.01.06	**_**	**Haul 1**	**Net 3**	**Depth (m) 55 - 6**			**Time 12.38 - 13.00**	**_**
Sprat	**length (cm)**	**tot.length (cm)**	**weight (g)**	**digestion rate**			**stomach fullness**	**Stomach content**
1	11	12,5	11,25	0		0	2	empty
2	6	7,5	2,78	0		0	2	empty
		3,5						
Average		10,0	7,0					

Natt 1

04.01.06	_	Haul 2	Net 1	Depth (m) 131 - 92					Time 19.31 - 19.47	_
Sprat	**length (cm)**	**tot.length (cm)**	**weight (g)**	**digestion rate**					**stomach fullness**	**Stomach content**
1	11,5	13,5	16,35		0		0		2	empty
2	10	11,5	10,24		1		1		2	1 calanus
3	10	11,5	10,21		0		0		2	empty
4	8,5	9,5	5,74		0		0		2	empty
5	10,5	12,5	11,15		0		0		2	empty
6	8	9	4,75		0		0		2	empty
7	8	9,5	5,47		3	4	4	3,667	3	3-4 calanus (3-4),remains (5)
8	7,5	8,5	3,41		0		0		2	empty
9	11	12	12,6		0		0		2	empty
10	7,5	8,5	3,63		0		0		2	empty
11	10	11,5	11,71		0		0		2	empty
12	10,5	12	11,87		0		0		2	empty
13	11,5	13,5	16,32		0		0		2	empty
14	11,5	13	15,85		0		0		2	empty
15	10,5	12	12,97		0		0		2	empty
16	9,5	11	8,33		0		0		2	empty
17	7,5	9	3,91		0		0		2	empty
18	8	9	4,53		0		0		2	empty
19	8	9,5	5,3		0		0		2	empty
20	7	8	3,52		0		0		2	empty
21	11	12,5	12,8		0		0		2	empty
22	10,5	12	11,5		0		0		2	empty
23	10,5	12	10,53		0		0		2	empty
24	8	10	5,71		0		0		2	empty
25	10	12	9,86		0		0		2	empty
26	9,5	11	7,77		0		0		2	empty
27	8,5	10	6,1		0		0		2	empty
28	9,5	11,5	8,55		0		0		2	empty

29	9	10,5	7,38	0		0		2	empty
30	10,5	12	10,56	0		0		2	empty
		1,6							
Average		10,9	9,0						

04.01.06	_	Haul 2	Net 2	Depth (m) 89 - 60,5				Time 19.48 - 20.03	_
Sprat	length (cm)	tot.length (cm)	weight (g)	digestion rate				stomach fullness	Stomach content
1	11	13	13,98	0		0		2	empty
2	12	14	15,72	0		0		2	empty
3	10	11,5	9,26	0		0		2	empty
4	10	11,5	9,57	0		0		2	empty
5	10	12	10,59	0		0		2	empty
6	8,5	9,5	5,54	0		0		2	empty
7	8,5	9,5	5,84	0		0		2	empty
8	8	9	4,21	0		0		2	empty
9	6	7,5	2,2	0		0		2	empty
10	6	7,5	2,41	0		0		2	empty
11	9,5	11	8,04	0		0		2	empty
12	9,5	11	8,25	0		0		2	empty
13	11	13	13,2	0		0		2	empty
14	8,5	10	6,22	0		0		2	empty
15	8	9,5	5,02	0		0		2	empty
16	7,5	8,5	3,63	0		0		2	empty
17	7,5	8,5	3,52	0		0		2	empty
18	7	8	2,87	0		0		2	empty
19	6,5	7,5	2,5	0		0		2	empty
20	7	8	2,8	0		0		2	empty
21	9,5	11,5	9,17	0		0		2	empty
22	10,5	12	11,77	0		0		2	empty
23	10	12	11,53	0		0		2	empty
24	12	14	16,3	0		0		2	empty
25	7	8,5	3,09	3	4	3,5	3,5	3	6 calanus(3)10-20 calanus (cop)(4)

26	7	8	3,11	5		5	3	
27	7	8,5	3,29	0		0	2	remains
28	7,5	9	3,59	0		0	2	empty
29	7	8	2,9	0		0	2	empty
30	7,5	8,5	3,91	0		0	2	empty
		2,0						
Average		10,0	6,8					

04.01.06	_	**Haul 2**	**Net 3**	**Depth (m) 56 - 4**			**Time 20.06 - 20.21**	_
Sprat	**length (cm)**	**tot.length (cm)**	**weight (g)**	**digestion rate**			**stomach fullness**	**Stomach content**
1	11	13	12,3	0		0	2	empty
2	10	11,5	9,63	0		0	2	empty
3	9,5	11	8,44	0		0	2	empty
4	9	10,5	6,17	0		0	2	empty
5	7,5	9	4,37	0		0	2	empty
6	8,5	10	5,33	0		0	2	empty
7	7,5	9	4,02	0		0	2	empty
8	7,5	8,5	3,51	5		5	2	remains
9	7,5	8,5	4,03	0		0	2	empty
10	7	8,5	3,04	0		0	2	empty
11	8,5	9,5	4,99	0		0	2	empty
12	9,5	11,5	8,85	5		5	2	remains
13	7,5	8,5	3,8	0		0	2	empty
14	7	8	3,03	0		0	2	empty
15	6,5	7,5	2,89	4	5	4,5	3	5calanus(4), copepod remains (5)
16	7,5	8,5	3,17	2		2	2	1 acartia (2)
17	7	8	3,03	0		0	2	empty
18	7	8,5	3,36	5		5	2	grøt ubest (5)
19	6	7	2,22	0		0	2	empty
20	6	7	1,95	4	5	4,5	3	1 copepode (4)
21	7	8	3,35	5		5	2	remains

	22	8	9,5	5,51	5		5	3	copepod remains
	23	8,5	9,5	4,54	5		5	3	copepod remains
	24	8	9,5	4,72	5		5	3	copepod remains
	25	7,5	9	3,76	0		0	2	empty
	26	6,5	7,5	2,36	0		0	2	empty
	27	7	8	2,92	0		0	2	empty
	28	6,5	7,5	2,16	4	5	4,5	3	2 calanus(4), copepod remains
	29	6,5	8	2,79	0		0	2	empty
	30	6,5	7,5	2,4	5		5	2	remains
			1,4						
Average			8,9	4,4					

Natt 2

04.01.06		Haul 3	Net 1	Depth (m) 56 - 37			Time 20.56 - 21.11	
Sprat	**length (cm)**	**tot.length (cm)**	**weight (g)**	**digestion rate**			**stomach fullness**	**Stomach content**
1	11	13	16,98	0		0	2	empty
2	11	13	14,04	0		0	2	empty
3	11	13	15,53	0		0	2	empty
4	11	13	13,34	0		0	2	empty
5	7,5	8,5	3,58	4		4	3	14 calanus
6	8	9,5	4,53	0		0	2	empty
7	7,5	9	3,82	2	3	5	3	1 onchea(2), acartia(3)?, calanus(3), remains (5)
8	7	8	2,92	4		4	2	pilorm(3),copepod remains
9	7,5	8,5	2,92	0		0	2	empty
10	6,5	7,5	2,18	0		0	2	empty
11	11,5	13,5	16,75	0		0	2	empty
12	9,5	11,5	7,49	0		0	2	empty
13	10,5	12,5	11,35	0		0	2	empty
14	7,5	9	4,31	0		0	2	empty
15	8,5	9,5	5,52	5		5	3	copepod remains
16	8,5	10	5,61	0		0	2	empty

17	9,5	11	8,72	0	0	2	empty
18	8	9,5	5,11	0	0	2	empty
19	7	8,5	3,43	5	5	2	remains
20	7,5	8,5	3,67	0	0	2	empty
21	7,5	8,5	3,29	0	0	2	empty
22	9	10,5	6,22	0	0	2	empty
23	9	11	7,5	0	0	2	empty
24	9,5	11	8,53	0	0	2	empty
25	6,5	7,5	2,28	0	0	2	empty
26	7	8,5	2,97	0	0	2	empty
27	8	9,5	5,04	0	0	2	empty
28	6,5	7,5	2,58	5	5	3	copepod remains
29	6,5	7,5	2,6	0	0	2	empty
30	7	8	2,63	0	0	2	empty
Average		9,9	6,5				

04.01.06	_	**Haul 3**	**Net 2**	**Depth (m) 35 - 21**		**Time 21.12 - 21.26**	_
Sprat	**length (cm)**	**tot.length (cm)**	**weight (g)**	**digestion rate**		**stomach fullness**	**Stomach content**
1	13,5	15,5	21,76	0	0	2	empty
2	11	13	15,01	0	0	2	empty
3	12	13,5	17,78	0	0	2	empty
4	9,5	11,5	9,43	0	0	2	empty
5	9	10,5	7,17	0	0	2	empty
6	8,5	10	5,82	0	0	2	empty
7	8	9	4,02	5	5	2	copepod remains
8	8	9,5	3,7	0	0	2	empty
9	6,5	7,5	2,37	0	0	2	empty
10	7	8	3,61	0	0	2	empty
11	11	12,5	14,45	0	0	2	empty
12	11	12,5	12,68	0	0	2	empty
13	11	12,5	12,87	0	0	2	empty

14	10,5	12	12,56	0		0	2	empty
15	10,5	12	10,44	0		0	2	empty
16	9,5	11	8,44	0		0	2	empty
17	9	10	6,61	0		0	2	empty
18	8	9	3,98	4	5	4,5	3	1 calanus (4), remains
19	7	8	2,65	5		5	2	remains
20	6	7	2,02	0		0	2	empty
21	11	12,5	13,96	0		0	2	empty
22	10,5	12	11,5	0		0	2	empty
23	10	11,5	9,88	0		0	2	empty
24	9,5	11	9,06	0		0	2	empty
25	9,5	11	8,8	0		0	2	empty
26	10	12	11,17	0		0	2	empty
27	7,5	8,5	3,52	5		5	3	remains
28	7,5	9	3,7	0		0	2	empty
29	7	8	2,75	0		0	2	empty
30	6,5	7,5	2,32	0		0	2	empty
Average		10,6	8,5					

04.01.06	_	**Haul 3**	**Net 3**	**Depth (m) 20 - 2,5**			**Time 21.27 - 21.40**	_
Sprat	**length (cm)**	**tot.length (cm)**	**weight (g)**	**digestion rate**			**stomach fullness**	**Stomach content**
1	10	11,5	9,03	0		0	2	empty
Average		11,5	9,0					

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05.01.06	_	**Haul 1**	**Net 1**	**Depth (m) 90 - 80**			**Time 11.22 - 11.43**	_
Sprat	**length (cm)**	**tot.length (cm)**	**weight (g)**	**rate of digestion**			**stomach fullness**	**gut content**

1	10,5	12,5	12,5	0			0	2	empty
2	8	9,5	9,5	5			5	2	remains
3	7,5	8,5	8,5	0			0	2	empty
4	7,5	9	9	5	3	1	3	3	remains, calanus ca 30(3), 1 temora(1)
5	7,5	8,5	8,5	0				2	
Average		9,6	9,6						

05.01.06		**Haul 1**	**Net 2**	**Depth (m) 80 - 70**				**Time 11.44 - 11.55**	
Sprat	**length (cm)**	**tot.length (cm)**	**weight (g)**	**rate of digestion**				**stomach fullness**	**gut content**
1	9,5	11,5	8,68	5				2	remains
		11,5	8,68						

05.01.06		**Haul 1**	**Net 3**	**Depth (m) 70 - 60**				**Time 11.56 - 12.12**	
Sprat	**length (cm)**	**tot.length (cm)**	**weight (g)**	**rate of digestion**				**stomach fullness**	**gut content**
1	10	12	10,2	0			0	2	empty
2	9,5	11,5	7,2	2			2	2	2 calanus
3	8,5	10	6,29	3	4	5	4	3	1 calanaus(3), 2-3 small not identified(4),remains(5)
4	8,5	10	5,47	3	5		4	3	temora?, remains
5	8,5	9,5	5,58	0			0	2	empty
6	8,5	9,5	5,31	0			0	2	empty
7	8,5	10	6,29	4			4	3	copepod remains
8	8	9	5,23	0			0	2	empty
9	9	10,5	6,02	0			0	2	empty
10	7,5	8,5	3,12	0			0	2	empty
11	7,5	9	3,52	0			0	2	1 pilorm(2)
12	8	9,5	4,81	5			5	3	remains
13	8	9	4	0			0	2	empty
14	7,5	8,5	3,09	4			4	3	3 large, prob calanus

15	7,5	8,5	3,91	2	3		2,5	3	12 calanus
16	8	9	4,31	4			4	3	remains, 1 calanus(?)
17	8	9	4,46	2			2	2	1 smaller than calanus
18	8	9	4,33	0			0	2	empty
19	7	8	3,14	2	3		2,5	2	3 calanus(3), 1 small(?)
20	7,5	8,5	3,4	2	3		2,5	2	4 calanus(2+3)
21	7,5	8,5	3,49	4	5		4,5	4	copepod remains
22	7,5	8,5	3,9	4			4	2	copepod remains
23	7,5	9	3,94	2	3		2,5	2	2 calanus, 1 metridia(?)
24	8	9	4,4	0			0	2	empty
25	7	8	3,08	5			5	2	remains
26	7,5	8,5	3,92	4			4	2	1 calanus
27	7,5	8,5	4,37	5			5	2	remains
28	7,5	9	3,94	2	3	5	3,333	2	1 calanus(2), 4 calanus(3), grøt
29	6,5	7,5	2,47	0			0	2	empty
30	7	8,5	3,25	0			0	2	empty
	7,5	9	4,01	5			5	2	remains
Average		9,1	4,5						

05.01.06		**Haul 2**	**Net 1**	**Depth (m) 128 - 129**	**Time 12.55 - 13.07**	
Sprat	**length (cm)**	**tot.length (cm)**	**weight (g)**	**rate of digestion**	**stomach fullness**	**gut content**
1	12	14	16,01	0	2	empty
2	12,5	14	17,62	0	2	empty
3	9	11	8,19	0	2	empty
4	8	9,5	4,64	0	2	empty
5	9	10,5	7,01	0	2	empty
6	8,5	10	5,6	0	2	empty
7	7,5	9	4,06	0	2	empty
8	7,5	9	3,94	0	2	empty
9	7	8,5	3,2	0	2	empty
10	10	12	11,2	0	2	empty

11	9,5	11,5	9,29	0	2	empty
12	10	12	10,74	0	2	empty
13	10	12	11,27	0	2	empty
14	10,5	12	11,46	0	2	empty
15	10	11	7,55	0	2	empty
16	10,5	12	10,8	0	2	empty
17	7	8,5	4,09	3	2	1 temora(?)
18	8,5	9,5	5,51	0	2	empty
19	6,5	7,5	2,83	0	2	empty
20	6,5	7,5	2,51	3	2	1 temora(?)
21	10	11,5	11,15	0	2	empty
22	10,5	12	10,31	1	2	1 calanus
23	11	12,5	14,33	0	2	empty
24	7	8	2,53	0	2	empty
25	7,5	9	3,89	0	2	empty
26	7	8	3,25	0	2	empty
27	10,5	12,5	13,06	0	2	empty
28	8	9	5,22	0	2	empty
29	9,5	11	9,19	0	2	empty
30	7,5	8,5	3,42	0	2	empty
Average		10,4	7,8			

05.01.06	**-**	**Haul 2**	**Net 2**	**Depth (m) 123 - 109**	**Time 13.12 - 13.35**	**-**
Sprat	**length (cm)**	**tot.length (cm)**	**weight (g)**	**rate of digestion**	**stomach fullness**	**gut content**
1	12	14	16,26	0	2	empty
2	9,5	11	7,96	2	2	temora
3	10,5	12	9,84	0	2	empty
4	7	8	3,17	0	2	empty
5	10	11,5	10,06	0	2	empty
6	7,5	8,5	4,54	0	2	empty
7	10	12	10,55	0	2	empty

	8	8,5	9,5	5,3		0	2	empty
	9	8	9,5	5,16		0	2	empty
	10	9	10,5	7,16		5	2	remains
	11	6,5	7,5	2,65		0	2	empty
	12	6,5	7,5	2,65		0	2	empty
	13	7,5	9	3,45		0	2	empty
	14	7	8,5	2,97		0	2	empty
	15	8,5	9,5	5,22		5	2	remains
	16	6,5	7,5	2,12		0	2	empty
	17	7	8	2,86		0	2	empty
	18	8	9,5	4,5		0	2	empty
	19	5,5	6,5	1,71		0	2	empty
	20	10	12	11,76		0	2	empty
	21	10,5	12,5	12,87		5	2	remains
	22	10	12	11,03		0	2	empty
	23	9,5	11	8,44		0	2	empty
	24	9	10,5	7,62		0	2	empty
	25	7	8,5	3,63		0	2	empty
	26	8	9,5	4,81		0	2	empty
	27	7	8	2,7		0	2	empty
	28	7,5	8,5	3,89		0	2	empty
	29	6	7	1,78		5	2	remains
	30	5	6	0,99		0	2	empty
Average			9,5	5,9				

05.01.06	_	Haul 2	Net 3	Depth (m) 103 - 83			Time 13.28 - 13.39	_
Sprat	**length (cm)**	**tot.length (cm)**	**weight (g)**	**rate of digestion**			**stomach fullness**	**gut content**
1	11	13	15,33		0	0	2	empty
2	11	12,5	12,57		0	0	2	empty
3	10	12	10,08		5	5	2	remains

Average		12,5	12,66

Gadoids

APPENDIX 6

24.11.2005		Haul 1	Net 2	Depth (m) 90-62	Time13.17-13.79	
Haddock	length (cm)	tot.length (cm)	weight (g)	digestion rate	stomach fullness	gut content
1	37	39	671	2+5	4	3 krill(2) and not identified(5)
2	45	48	1143	**2,3,5**	4	7 krill(2+3) ant Meg.norvegica, remains(5)
Average	41	43,5	907			

25.11.2005		Haul 1	Net 2	Depth (m) 86-58	Time 10.17-10.36	
Haddock	length (cm)	tot.length (cm)	weight (g)	digestion rate	stomach fullness	gut content
1	44	48	1174	1,2,3	5	46 krill(1-2), børstemark, 14 krill(3), musling?,pectinaria?(3)

13.12.05		Haul 3	Net 3	Depth (m) i multinettåpning	Time 18.40 - 18.55	
Whiting	length (cm)	tot.length (cm)	weight (g)	digestion rate	stomach fullness	gut content
1	23	25,5	116,84	5	3	remains

13.12.05 **Haul 4** **Net 1** **Depth (m) 60 - 40** **Time19.37 - 19.52**

Whiting	length (cm)	tot.length (cm)	weight (g)	digestion rate			stomach fullness	gut content
1	25	28	163	4	5		3	1 brisling, 3-4 krill, remains

19.12.05 **Haul 2** **Net 1** **Depth (m) 153 - 146** **Time day**

Whiting	length (cm)	tot.length (cm)	weight (g)	digestion rate			stomach fullness	gut content
1	?							

04.01.06 **Haul 1** **Net 2** **Depth (m) 91 - 61** **Time 12.19 - 13.00**

Whiting	length (cm)	tot.length (cm)	weight (g)	digestion rate			stomach fullness	gut content
1	31,5	34	293	4			3	4x2 krill eyes, remains of krill(4)

04.01.06 **Haul 2** **Net 3** **Depth (m) 56 - 4** **Time 20.06 - 20.21**

Whiting	length (cm)	tot.length (cm)	weight (g)	digestion rate			stomach fullness	gut content
1	27	29	197	1	2		3	1 krill

04.01.06		Haul 3	Net 1	Depth (m) 56 - 37			Time 20.56 - 21.11	
Whiting	length (cm)	tot.length (cm)	weight (g)	digestion rate			stomach fullness	gut content
1		31	212	2	3		5	1 sprat(2)
2		25,5	121	3			3	1 krill (3), 2 eyes
Average		28,3	166,5				4	

04.01.06		Haul 3	Net 2	Depth (m) 35 - 21			Time 21.12 - 21.26	
Whiting	length (cm)	tot.length (cm)	weight (g)	digestion rate			stomach fullness	gut content
1	32	34	246	2			3	2 krill
2	30	32	243	2	4		3	1 krill, krill remains(4)
3	31	33	262	2			3	1 krill
4	31	33	302	2	3		3	1 krill(2), 1 krill (3)
5	39	41	478	2	3		4	4 krill(2++3)
6		28	158	0			2	empty
7		28	177	2			2	2 krill(2)
8		27	141	2			5	5 krill(2)
9		26,5	123	5			3	1 krill(2), remains with 2 eyes (5)
Average		31,4	236,7	2,1			3,1	
fisk med snøre:	32	34	280	5	3		grøt	

05.01.06		Haul 1	Net 1	Depth (m) 90 - 80			Time 11.22 - 11.43	
Whiting	length (cm)	tot.length (cm)	weight (g)	digestion rate			stomach fullness	gut content
1		37	398	2	3	4	3	1 krill(2) 2(?) krill(3-4)

2		34	308	0		2	empty
3		34	397	2	3	5	10 krill(2+3)
4		31,5	235	3	5	5	1 brisling(3), 1 krill(3), 4 eyes krill, grøt(5)
5		29	177	0	5	2	remains
6		32	238	4	5	3	1 sprat(4), remains(4+5)
7		31	253	3		3	2 krill(3)
8		29,5	196	3		5	1 sprat(4), remains(4+5)
9		27	145	3		2	remains
10		28	161	0		2	empty
11		26,5	124	3		3	1 krill
Average		30,9	239,3	2,1		3,2	

05.01.06		**Haul 2**	**Net 1**	**Depth (m) 128 - 129**		**Time 12.55 - 13.07**	
Whiting	**length (cm)**	**tot.length (cm)**	**weight (g)**	**digestion rate**		**stomach fullness**	**gut content**
1		35,5	371	5	4	3	remains, børstemark(4)?
2		31	243	3	5	3	2 krill(3), remains(5)
Average		33,25	307	4		3	

05.01.06		**Haul 2**	**Net 3**	**Depth (m) 103 - 83**		**Time 13.28 - 13.99**	
Whiting	**length (cm)**	**tot.length (cm)**	**weight (g)**	**digestion rate**		**stomach fullness**	**gut content**
1		27	169	5		2	remains